REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
22 AUG 97

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
UNDERUTILIZATION VS POTENTIAL: CLOSING THE TECHNOLOGY GAP IN THE CLASSROOM

5. FUNDING NUMBERS

6. AUTHOR(S)
JOHN HIGGS

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
UNITED STATED AIR FORCE ACADEMY, CO 80840

8. PERFORMING ORGANIZATION REPORT NUMBER
97-108

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
DEPARTMENT OF THE AIR FORCE
AFIT/CI 2950 P STREET
WRIGHT-PATTERSON AFB OH 45433-7765

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION AVAILABILITY STATEMENT
DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

DTIC QUALITY INSPECTED 2

14. SUBJECT TERMS

15. NUMBER OF PAGES

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT

18. SECURITY CLASSIFICATION OF THIS PAGE

19. SECURITY CLASSIFICATION OF ABSTRACT

20. LIMITATION OF ABSTRACT

Underutilization vs Potential: Closing the Technology Gap in the Classroom

Dee L. Fabry
University of Colorado at Denver
Campus Box 106, P.O. Box 173364
Denver, CO 80217-3364
Voice: 303/759-8836 Fax: 303/556-4479
E-mail: deefabry@aol.com

John Higgs, Major, USAF
United States Air Force Academy
2354 Fairchild Drive, Suite 6A6
USAF Academy, CO 80840
Voice: 719/333-3255 Fax: 719/333-3251
E-mail: jrhiggs@kktv.com

Underutilization vs. Potential: Closing the Technology Gap in the Classroom

Abstract

While the number of computers in the classroom continues to increase and tremendous support for technology integration exists in government, business, and academia, a major discrepancy exists between the level of technology use expected of educators and the actual use and integration of technology in the classroom. This paper examines barriers that impede the effective use of technology in education.

Introduction

The technology-school link dominates as one of the top issues in education today (National Education Summit, 1996). Many government and business leaders believe that technology, thoughtfully integrated into the curriculum, provides students with the skills necessary to compete and survive in the 21st century. Despite this support and the huge investment public education has made in acquiring technology for schools, concern exists that computers remain underutilized (Marcinkiewicz, 1993). Research focusing on teacher's expected and actual use of technology confirm this pattern (Duffield, Walster, Higgs, Fabry, & Grabinger,1996).

Since the belief exists that technology can increase learning (Kulik & Kulik, 1991; Pisapia & Perlman, 1992; Ryan, 1991; Fletcher-Flinn & Gravatt, 1995) and provide valuable life skills to American students, the successful integration of computers into schools depends largely on how teachers embrace and use computers (Marcinkiewicz, 1993; Evans-Andris, 1995). The educational potential computers possess will not be fully realized unless teachers embrace and understand how to effectively use them (Hunt & Bohlin, 1993). This paper examines why a gap exists between the actual and expected use of computers. Specifically, we address (a) teachers' attitudes toward integrating and using technology, (b) the barriers that preclude effective

technology integration and use, and (c) how teachers actually use technology in the classroom. The answers this paper provides should help educational policy-makers establish appropriate intervention strategies to narrow the disparity between computer availability and computer use.

Technology Use and Student Achievement

Since the first computer entered public education, literally thousands of studies have investigated the educational effects. Although criticism and controversy exists, much of this literature demonstrates technology's positive effects on achievement. Space limitations prevent an exhaustive presentation of this research, therefore we present studies (meta-analyses and longitudinal studies) representative of the major research approaches, as well as some of the criticisms of the approaches.

Meta-analyses

Meta-analysis is a method of assessing the statistical results from many different studies into a single finding by using effect size (Krathwohl, 1993). The effect size is a score in standard deviation units. An effect size of .3 means that the average person in the treatment group performs about .3 standard deviations better than the average person in the control group. Kulik and Kulik (1991) performed a meta-analysis of 254 studies examining the effects of computer-based instruction for kindergarten students through the college level and found an effect size of 0.3.

The studies in their meta-analysis met four criteria: (a) The studies took place in a classroom involving real teaching, (b) there was both a control group and an experimental group to provide quantitative data, (c) the methodologies were very sound, and (d) the studies have to be accessible from university or college library resources. These results have been corroborated by many other researchers as well. For example, Khalili and Shashaani (1994) completed a meta-analysis of studies completed between 1988 and 1992 and found an effect size of .38. These studies indicate the potency of computer-based education. Interactive Educational Systems Design (1996), an independent consulting firm, contracted with the Software Publishers Association to perform a meta-analysis of the effectiveness of technology in schools.

One hundred and seventy-six studies conducted from 1990 to 1995 were analyzed. The report concludes that technology positively impacts education. Important findings include: (a) Positive effects exist throughout education (preschool through higher education), for both regular and special needs students in all major subject areas; (b) technology positively affects student attitudes toward learning and self-concept; and (c) technology introduction enhances cooperation and collaboration, increasing teacher-student and student-student interactions.

Criticism of Technology's Effects

Results of the magnitude reported above lead proponents to extol the benefits and potential of technology. However, other researchers remain skeptical. McKenzie believes that most research focusing on technology and student achievement has examined performance on basic skills rather than measuring gains in higher-order skills (cited in Wellburn, 1996). Many, if not

most, of the studies comprising the meta-analyses above report results from drill and practice applications. Additionally, these meta-analyses attribute effect to medium (computer) alone, igniting considerable debate among researchers. Clark (1983; 1994), for example, believes that instructional methods embedded in the medium influences learning; whereas, Kozma (1991), believes that the medium and methods combine to interact with and influence how students learn and process information. These criticisms lead Means, et al. (1993) to write "The accumulation of comparative studies, biased in their choice of control groups or outcome measures, does little to help us understand what features of the treatment are critical for producing the desired effects" (p. 76). These limitations have given rise to longitudinal studies and other contextual approaches (Means, et al., 1993) which demonstrate technology's potential for supporting a learner-centered approach to education.

Longitudinal Studies

Apple Computer, Inc. (1995) began its Apple Classrooms of Tomorrow (ACOT) project in 1985 to explore what happens to students and teachers when they have access to computers whenever they need it. They supplied computers and trained the teachers at two sites initially, adding more sites, teachers, and students over the years. Dwyer (1994) reports that during the eight years of this study, ACOT researchers witnessed remarkable improvements in the nature of instruction, learning, assessment, and the school culture. Apple's (1995) comprehensive ACOT research demonstrates that technology significantly increases the potential for learning.

The Computers Helping Instruction and Learning Development (CHILD) study, which started in 1987, investigated the impact of computers on over 1,400 students and their teachers from nine Florida elementary schools (Kromhout & Butzin, 1993). Each participating teacher received technical training with the computers, as well as training emphasizing a team approach with other participating teachers. Three to six computers were placed in each participating classroom. Curriculum and computers were totally integrated. Results of the study showed positive and statistically significant changes in standardized test scores for all participating grades and schools. The largest effects appeared for students involved in the program for greater than one year. At the conclusion of the study in 1992, none of the schools expressed dissatisfaction with the project. In fact five schools planned to expand their level of participation, and nine new schools were about to join CHILD (Kromhout & Butzin, 1993). These longitudinal studies, as well as other contextual-based research (see also Means, et al, 1993, for a short synopsis), support the contention that technology can increase student learning and provide valuable life skills to students.

The Status of Educational Computing

Since 1975, computers have moved into U.S. schools at an unprecedented rate (Sutton, 1991). Becker (1983) reports that by 1981 the majority of secondary schools owned at least one computer and, by 1985, over 90% of public schools owned at least one microcomputer (Office of Technology Assessment, 1987). The Office of Technology Assessment (1995) estimated that by

the spring of 1995, 5.8 million computers will call K-12 schools home; about one computer for every nine students. Despite this large investment in computers by schools and the vast body of literature demonstrating how a technology-rich educational environment benefits learners, why does Marcinkiewicz (1993) find in his study that computers are underutilized? Or as Peck and Dorricott (1994) phrase it, "Why do schools rumble along virtually unchanged by the presence of computers" (p. 11)?

Factors Affecting the Implementation of Technology

Resistance to Change

Barriers to the effective use of technology involve teachers' attitudes and resistance to change, concerns about funding, training deficiencies, and inadequate access (OTA, 1995; National Education Summit, 1996). Teachers themselves identify the need for administrative support, adequate funding, time, and training as essential to facilitate change (Norum, Grabinger, & Duffield, 1996). Although the education summit attendees rank staff development as the most significant barrier, perhaps an innate dislike for change (especially change mandated from above) is the most basic and significant barrier to technology integration. Cohen (cited in Hodas, 1996) points out that schools and the nature of teaching have remained relatively unchanged for hundreds of years. Therefore, any reform or policy that disrupts the stable nature of schooling represents a threat that will result in immense resistance (Hodas, 1996).

The tendency in schools is to assimilate anything new and threatening in a manner that causes the least disturbance (Tucker, cited in Budin, 1991). To integrate technology into classroom

practice in the manner envisioned by ardent proponents, teachers must really make two radical changes--not only must they learn how to use technology, but they must also fundamentally change how they teach. Teachers are being asked to move away from relying on a teacher-centered classroom to a more student-centered classroom. This represents a more difficult transition for teachers than simply using technology (Means & Olson, 1995).

In addition to a basic resistance to change, Marcinkiewicz (1994) believes that people avoid using computers because they fear a loss of status and hard-earned skills and do not have adequate knowledge. The literature corroborates this assessment. For example, Budin (1991) states that since the introduction of microcomputers into schools there has been an undercurrent of teacher anxiety about computers because teachers worry about how computers will affect student learning and their own work. Some teachers fear they might be replaced by computers while others fear losing control of the classroom. Additionally, since many teachers are likely to know less about computers than their students, the fear of embarrassment acts as a major deterrent to acquiring the skills required to effectively use computer technology in the classroom (Hodas, 1996). Finally, the manner in which change occurs impacts success. School reform requires a collaborative effort on the part of all people involved in the educational system, a strong, visionary leadership, modification of the organizational structure, and staff development (Russell, Sorge, and Brickner, 1994). Unfortunately, when it comes to the integration of technology into the education system, computers have, by and large, been forced onto the education system, not as a tool to complement and enhance the curriculum, but as an end unto themselves (Young, 1991). In addition to the fact that computers are often mandated

from above, appropriate training to develop teacher's skills appears to be an afterthought (Young, 1991). Mandated change in education typically results in superficial adoption rather than incorporating the substance (Means, et al. 1993). Change initiated from the bottom up works only as long as the teacher's who participate in the innovation are supported (Paul, 1994; Orwig, 1994).

Evans-Andris (1995) echoes the resistance factor in her study that found while teachers develop informal computing styles in response to computer introduction the majority adopt an avoidance strategy. This supports Smith and O'Day's (cited in Means & Olson, 1993) contention that teachers simply close their doors and teach just as they were taught.

Teachers' Attitudes

A related area concerning the mismatch between potential and actual use of computers by teachers involves teachers' attitudes. The attitudes of teacher's are reflected in the innovation and adoption categories discussed by Rogers (1995). Using Rogers model adopters of technology fall into one of five general categories: innovators, early adopters, early majority, late majority, and laggards. The innovators are eager to try new ideas and are at the forefront of technology use. Early adopters follow the innovators and are the successful users of technology. They serve as role models for others. They share with others their successes and encourage the use of technology. Early majority users wait to see how the technology is used and how successful it can be before using it. They are deliberative and cautious in the adoption of technology. Late majority users wait until they are either pressured into using technology or are finally persuaded

of the benefits. Laggards are the last to adopt. The attitudes of teachers and how they use technology fall into one or more of these categories. Unfortunately only 16% of educators fall into the innovator and early adopter categories where positive attitudes prevail.

Several studies have examined teachers' attitudes toward school use of computers and anxiety about computers. For example, Koohang (1987) found that male teachers exhibited more favorable attitudes toward computers than female teachers, teachers with more computer experience showed greater positive attitudes toward using computers, and teachers exposed to programming and/or instructional applications of computers were more favorably disposed to computer use. Expanding on previous research in this area, Marcinkiewicz (1994) studied how a set of internal variables (perceived self confidence with computers, perceived relevance of computers to teaching, teacher locus of control, innovativeness, and demographic data concerning the teachers' previous computer experience) affect the levels of computer use of practicing and preservice elementary school teachers. He found that teachers' computer use relates closely to self competence and innovativeness. Marcinkiewicz believes that staff development programs that take into account motivational variables should improve teachers' effectiveness with computers. Budin's (1991) work shows that teachers can transform education and become the facilitators of learning through the use of technology.

Professional Development: Training, Time, and Support

Teachers must be empowered to make decisions about technology (Budin, 1991) and must be given the time, training, and support to have the skills to make technology transformational.

Learning new skills in any profession requires time, however teachers have little time left after spending the great majority of their day instructing students in class, meeting with parents, and attending staff and committee meetings (OTA, 1995). Even accomplished, highly motivated technology-using teachers rank lack of time as among the most problematic barriers to integrating computers into schools (Sheingold and Hadley,1990). Teachers require time to experiment with technology, share their experiences with colleagues, and attend technology-related in-service training programs.

In addition to time constraints, limited spending by school districts significantly reduces training and support. Typically only four to fifteen percent of a school district's technology budget is spent on training. Only six percent of elementary schools and three percent of secondary schools have a full-time on-site technology coordinator (OTA, 1995). The lack of professional development represents a very significant barrier to technology integration. Teachers cannot be expected to use technology effectively unless they are taught how and when to use it (Young, 1991).

<u>Access</u>

Despite the impressive number of computers schools possess (approximately 5.8 million), a large number of teachers report little or no use of classroom computers for instruction (OTA, 1995). However, numbers alone do not guarantee adequate access. Access is more than simply the availability of technology in a school. Access involves locating the proper amount and right types of technology where teachers and students can effectively use them.

Effective access requires connectivity, ubiquity, and interconnectivity (Jones, Valdez, Nowakowski, & Rasmussen, 1994). Connectivity provides the capability to access rich resources within and beyond school. Ubiquity means locating the computers and peripherals where everyone within the school has access to them when they need them. Interconnectivity allows teachers and students to communicate and collaborate. With 5.8 million computers and a 9-to-1 student to computer ratio, why is access a problem?

The OTA Report (1995) provides some insights. While the United States leads the world in sheer numbers of instructional computers, half of these computers are 8-bit machines, incapable of supporting CD-ROM sized data bases, running complex software, or being networked. The computers in use are predominately used for lower-order thinking skill activities such as drill and practice. About one-half of the computers are located in centralized computer labs, in media centers, or in teacher's offices. These are not accessible to students on a daily basis. In addition, telephones, fax machines, and modems are usually located in the main office and are accessible only during restricted hours. Thirty-eight percent of schools have a modem and only 9 percent have access to the Internet. Less than one teacher in eight has a classroom telephone. The technology is either nonexistent, outdated, inaccessible or used ineffectively. Based on the requirements of connectivity, ubiquity, and interconnectivity, clearly access presents a problem to effective integration and use of technology for educators today.

A final issue impacting access involves the inequity in computer resources among schools. Enormous variability exists in student-computer ratios from school-to-school both within and across school districts (OTA, 1995). One elementary school might have a ratio of one computer

to 35 students, while another may average one to seven. Students in inner city schools and poorer neighborhoods suffer more from this inequity (OTA, 1995). Equitable distribution presents equity issues for learning. The Benton Foundation (1995) believes unequal access represents one of the biggest concerns to connecting the nation's classrooms.

Cost

Typically, schools focus on the obvious initial costs associated with buying hardware, without giving much consideration to the costs associated with software acquisition, maintenance and repair, training and technical staffing, replacement and system upgrades, and telecommunications connections (Means & Olson, 1995). In the aggregate, schools spend approximately $2.7 billion dollars per year on technology, however Rothstein (as cited by the Benton Foundation, 1995) estimates the installation cost of providing up-to-date computers linked to a communications network could cost between $11.8 and $30 billion initially ($267 to $625 per student), with annual operating costs running between $1.9 and $4.9 billion ($42 to $112 per student). These costs just represent hardware acquisition. In addition, due to differences in school location and drastic differences in existing resources and infrastructure (inadequate wiring and electrical power, air conditioning, ventilation, lighting, and security systems), the GAO (as cited by the Benton Foundation, 1995) estimates that it will require about $112 billion to repair and upgrade all school facilities to accommodate full use of technology. Despite the increasing affordability of technology, costs of this magnitude represent a significant barrier to technology integration.

Conclusion

Research studies report that there is a significant underutilization of technology in schools. The major issues in the implementation and integration of technology into classrooms today are: resistance to change, teacher's attitudes, training, time, access, and cost. Model programs such as ACOT and CHILD show that these barriers can be removed and technology can meet its potential to transform education. Until these issues are addressed on a broader scale, the integration of technology will continue to be a major concern to our nation.

In order to close the gap between the potential and actual use of computers and other technologies in the classroom we must concentrate our efforts on providing resources to the group that can make the major impact with technology, our teachers. It is not enough to simply put computers into schools. Projects that show improvements in instruction, integration, and learning are those that concentrate on teacher training and place computers where they are readily accessible to educators and students, in the classroom. The training must be customized to show teachers how to effectively use technology, making a strong connection between their own teaching style and how technology can enhance their classroom instruction. If the next ten years are to look any different than the last ten, we must focus time, money, and resources in the areas that can have the greatest impact for our students, our teachers.

References

Apple Computer, Inc. (1995). Changing the conversation about teaching, learning, and technology: A report on 10 years of ACOT research.

Becker, H. J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. Computing in Education, 26 (3), 291-321.

Becker, H. J. (1983). School uses of microcomputers: Reports from a national survey. No. 1.Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.

Benton Foundation (1995, September). Communications Policy Project: The Learning Connection. [On-line]. Available http://www.benton.org/cgi-bin/lite/Goingon/learning.html

Budin, H. R.(1991). Technology and the teacher's role. Computers in the Schools, 8, 15-26.

Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42 (2), 21-29.

Clark, R. (1983). Reconsidering research on learning with media. Review of Educational Research, 53, 445-459.

Collins. A. (1991). The role of computer technology in restructuring schools. Phi Delta Kappan, 28-36.

Duffield, J.A., Walster, D., Higgs, J.R., Fabry, D.L.& Grabinger, R.S. (1996). The gap between potential and actual use of technology in the classroom. Unpublished manuscript.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. Educational Leadership, 51, 4-10.

Dyrli, O. E. and Kinnaman, D. E. (1995). Connecting classrooms: School is more than a place! Technology and Learning, 15 (8), 82-88.

Evans-Andris, M. (1995). An examination of computing styles among teachers in elementary schools. Educational Technology Research & Development, 43 (2), 15-31.

Fletcher-Flinn, C. & Gravatt, B. (1995) The efficacy of computer assisted instruction (CAI): A meta-analysis. Journal of Educational Computing Research, 12(3), 219-242.

Hawkins, J. (1996). Technology in Education: Transitions. [On-line].Available:http://www.summit96.ibm.com/brief/papers/transit.html#reading

Hodas, S. (1996). Technology refusal and the organizational culture of schools. [On-line]. Available: http://homepage.seas.upenn.edu/~cpage/techref.html

Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1994). Designing learning and technology for educational reform. North Central Regional Educational Laboratory.

Khalili, A. and Shashaani, L. (1994). The effectiveness of computer applications: A meta-analysis. Journal of Research on Computing in Education, 27(1), 48-59.

Kozma, R. B. (1991). Learning with media. Review of Educational Research, 61 (2), 179-211.

Kromhout, O., & Butzin, M. (1993). Integrating computers into the elementary school curriculum. Journal of Research on Computing in Education, 26 (1).

Kulik, C. C., & Kulik, J. (1991). Effectiveness of computer-based instruction: An updated analysis. Computers in Human Behavior, 7 (12), 75-94.

Marcinkiewicz, H. R. (1994). Differences in computer use of practicing versus preservice teachers. Journal of Research on Computing in Education, 27 (2),184-197.

Marcinkiewicz, H. R. (1993). Computers and teachers: Factors influencing computer use in the classroom. Journal of Research on Computing in Education, 26 (2), 220-237.

Means, B, & Olson, K. (1995). Restructuring schools with technology: Challenges and strategies. SRI International.

Means, B., & Olson, K (1994). The link between technology and authentic learning. Educational Leadership, 51, 15-18.

Means, B, Blando, J., Olson, K., Middleton, T., Morocco, C., Remz, A., & Zorfass, J. (1993). Using technology to support education reform. (Department of Education Publication No. OR 93-3231). Washington DC: U.S. Government Printing Office.

Miller, L. and Olson, J. (1994). Putting the computer in its place: A study of teaching with technology. Journal of Curriculum Studies, 26 (2), 121-144.

Norum, K., Grabinger, R.S., & Duffield, J.A. (1996). Healing the universe is an inside job: Revelations of professional selves and practices. Unpublished manuscript.

Orwig, A.H. (1994) Begin with teachers and watch students benefit. Technology and Learning, 15(1), 74-76.

Paul, D. (1994) An integration/inservice model that works. T.H.E. Journal, 21(9), 60-62.

Peck, K. L., & Dorricott, D. (1994). Why use technology? Educational Leadership, 51, 11-14.

Piapia, J., & Perlman, S.M. (1992). Learning technologies in the classroom: A study of results. Richmond: Metropolitan Educational Research Consortium.

Rogers, E.M. (1995). Diffusion of innovations (4th ed.) New York: The Free Press.

Russell, J. D., Sorge, D., and Brickner, D. (1994). Improving technology implementation in grades 5-12 with the ASSURE model. T.H.E. Journal, 21 (9), 66-70.

Ryan, A. (1991). Meta-analysis of achievement effects of microcomputer applications in elementary schools. Education Administration Quarterly, 27 (2), 161-184.

Sheingold, K., & Hadley, M. (1990). Accomplished teachers: Integrating computers into classroom practice. Center for Technology in Education. New York.

Software Publishers Association (1996). Report on the effectiveness of technology in schools, '95-'96. Washington DC.

Sutton, R. E. (1991). Equity and computers in the schools: A decade of research. Educational Technology Research and Development, 61 (4), 475-503.

U.S. Congress, Office of Technology Assessment. (1995). Teachers and technology: Making the connection. (OTA-EHR-616). Washington, DC: U.S. Government Printing Office.

U. S. Congress, Office of Technology Assessment (1987). Trends and status of computers in schools: Use in chapter 1 programs and use with limited english proficient students. (ED 291 337). Washington, DC: U.S. Government Printing Office.

Wellburn, E. (1996). The status of technology in the education system: A literature review. [On-line]. Available: http://www.etc.bc.ca/lists/nuggets/EdTech_report.html

Young, E. B. (1991). Empowering teachers to use technology in their classrooms. Computers in the Schools, 8, 143-145.

1996 National Education Summit Policy Statement.
[On-line]. Available: http://www.summit96.ibm.com/brief/finaledpol.html

Integrating Technology into the Classroom:

Teacher Attitudes and Barriers

John Higgs, Major, USAF
United States Air Force Academy
2354 Fairchild Drive, Suite 6A6
USAF Academy CO 80840
Voice: 719/333-3255 Fax: 719/333-3251
E-mail: HiggsJR.34EDG@USAFA.AF.MIL

Judith A. Duffield
University of Colorado at Denver
Campus Box 106, P.O. Box 173364
Denver, CO 80217-3364
Voice: 303/556-8445 FAX: 303/556-4479
E-mail: duffield@carbon.cudenver.edu

Dee L. Fabry
University of Colorado at Denver
Campus Box 106, P.O. Box 173364
Denver, CO 80217-3364
Voice: 303/705-8839 FAX: 303/556-4479
E-mail: fabry.dee@ingenius.com

Dian E Walster
University of Colorado at Denver
Campus Box 106, P.O. Box 173364
Denver, CO 80217-3364
Voice: 303/556-4365 FAX: 303/556-4479
E-mail: dwalster@carbon.cudenver.edu

R. Scott Grabinger
University of Colorado at Denver
Campus Box 106, P.O. Box 173364
Denver, CO 80217-3364
Voice: 303/556-4364 FAX: 303/556-4479
E-mail: sgrabing@carbon.cudenver.edu

Abstract

This study examines the attitudes teachers have toward technology, the actual and intended uses they have for technology, and the barriers that impede the effective use of technology in education. Twenty-two teachers enrolled in a master's degree program in information and learning technologies were the subjects. An attitude survey was administered and follow-up interviews and observations were made. While these teachers were eager to use technology in their classrooms, most had limited access. This study found lack of access, cost, and prohibitive policies to be the biggest barriers to technology use.

The Office of Technology Assessment (OTA) (U.S. Congress, 1995) identified three major barriers to technology use in schools: (a) access to technology, (b) the lack of a vision and goals for technology use, and (c) teacher training and support. Is removing these barriers sufficient for the integration of technology into the classroom? Will trained teachers agree with the vision and change the way they teach? The purpose of this study was to examine these and other barriers by exploring teacher attitudes toward and actual uses of technology. This study investigated the following questions:

1. What are teachers' attitudes toward integrating and using technology?
2. What barriers to technology use exist for this group of teachers and how were they overcome?
3. How do teachers actually use technology in the classroom?
4. If differences exist between intentions and use, what accounts for these differences?

Gaining an insight into what teachers would like or intend to do with technology can begin to answer these questions.

Methodology

Subjects

The sample for this study consisted of 22 teachers from several schools in a large Western state. Thirteen were elementary school teachers and nine were secondary school teachers. All teachers were enrolled in a masters' degree program in information and learning technologies. This technology-oriented masters' degree program was designed to promote technology integration into classroom practice,

therefore, each teacher had to meet two criteria for participation:

- possess an interest in technology applications to teaching, and
- have access to computers and other technologies, either in school or at home.

Prior experience with technology varied widely. Some of the teachers felt only moderately comfortable with word processors, while others taught HyperStudio programming or were responsible for laying the wires for their school computer network.

Procedure

This study used survey and qualitative research methods to provide a rich picture of teachers' attitudes and intentions toward technology, as well as actual classroom technology practices.

Previous research has examined correlations between specific teacher attitudes toward technology — whether teachers like computers or not, feel comfortable with computers, etc. — and actual use, but little research exists linking teachers' attitudes with intentions toward technology use. This study used the Fishbein and Ajzen model of attitude-behavior consistency to link attitudes and subjective norms to teachers' intentions to use technology in the classroom. The Fishbein-Ajzen model is the dominant theoretical framework in attitude-behavior measurement because it provides collection of consistent and reliable information about attitudes, intentions, and behaviors (Eagly & Chaiken, 1993; Walster, 1994). Our questionnaire contained the following types of questions:

- *General attitude questions* designed to provide a global perspective concerning the respondents' attitudes toward using technology in the

classroom;

- *General intention question* designed to provide a global intent toward using technology in the classroom
- *Attitude questions* about *specific types of technologies;*
- *Intention questions* about *specific types of technologies*; and
- *Behavior questions* asking how the respondents actually had *used specific types of technologies* in the classroom.

The questions were constructed using a traditional semantic differential (see Figures 1 and 2 for examples). The questions addressing teachers' attitudes toward specific technologies were scored on a seven point semantic differential scale, ranging from extremely favorable to extremely unfavorable. The questions measuring intentions and behaviors were scored on a four point semantic differential scale, ranging from frequently to never. The examples in Figure 1 show a general attitude question and its related intention question. The examples in Figure 2 show a specific technology attitude question and its related intention and behavior questions.

Insert Figure 1 about here.

Insert Figure 2 about here.

The Fishbein-Ajzen method provides an understanding of the attitude structure concerning behavior (Walster, 1994). Since our sample was limited, and in order to provide the rich detail the survey undoubtedly missed, we also observed

and interviewed four teachers selected at random. These teachers represented four different schools from three different school districts and provide breadth to our study.

Results

Questionnaire Data

The five types of questions were grouped into the following three categories: (a) general attitude questions; (b) general intention question; and (c) questions designed to locate the respondents' attitudes, intentions, and behaviors toward using specific types of technology in the classroom. Each table presents means and standard deviations for the questionnaire variables.

Answers to the general attitude questions (see Table 1) indicate that these teachers possess quite favorable attitudes toward technology and are generally favorably disposed to using technology. The last question in Table 1 indicates that other people do not influence these teachers.

Insert Table 1 about here.

The mean answer to the general intention question (see Table 2) indicates that these teachers intend to use instructional technology frequently to very often when they teach.

Insert Table 2 about here.

The answers to the questions related to specific technologies are summarized

in Table 3. Generally, the means decrease from attitude, to intention, to behavior. Although the respondents have fairly positive attitudes toward instructional technologies, they are less favorably disposed to use them. This is especially true for the world wide web, Internet, interactive video, and on-line services. Perhaps this reflects the fact that they do not have access to these forms of instructional technologies in their schools or at home. As a group these teachers display a very positive attitude toward new technologies, when the technology is not named (see last entry in Table 3), with similar intent to use new technologies. When the technology is named, the attitudes are less positive.

Insert Table 3 about here.

As discussed above, these teachers possess favorable attitudes toward technology and are generally favorably inclined to use technology. The questionnaire data suggests that these teachers are receptive to integrating technology into classroom practice. However, a significant falloff occurs in actual classroom use of technology (in particular computer-based technologies) which indicates the presence of barriers to use. The interview and observation data provided the means to more deeply address these issues.

Observation Data

School Descriptions. School 1 (a K-6 elementary school) consolidated all computers in three laboratories. One computer lab consisted of 12 Macintosh LCII and III machines and a Centris 660 multimedia station. A second lab consisted of 19 Apple IIgs computers. The third lab consisted of 15 Apple IIe computers. Each

classroom had one computer per classroom, strictly for teacher use. This school did not have Internet access.

School 2 (a K-6 elementary school) allocated computers to two computer labs, the classrooms, and the school hallways. School 2 outfitted a basic computer lab with 28 Macintosh LC475 computers and a multimedia lab with 14 Macintosh LC575 computers, a scanner, and two laser printers. The basic lab was used for word processing and basic applications; the multimedia lab for student projects. In addition, School 2 provided two computers and a printer per classroom, as well as at least two computers and an accompanying printer in each school hallway, and several computers in the library. This school possessed two Internet connections, one in the multimedia lab and one in the library.

School 3 (a K-6 elementary school) allocated three IBM computers and a deskjet printer to each classroom. The library possessed nine IBM computers distributed around the periphery of the room. These computers were networked to a HP4 laser jet printer. One computer lab adjoining the library had 29 IBM computers networked to two HP4 laser jet printers. Internet access was provided via the library. While wandering around this school we saw four students using the library computers, two were working on math and two were working on writing. We also noticed a class working in the computer lab. A banner in the computer lab read: "Technology is the pattern that connects all learners to the future." The sign-in log shows and the librarian confirmed that this lab was used every day, all day, in 20 minute increments. According to the librarian, this school was two years old and designed for technology use.

School 4 (a middle school) had three computer labs equipped with Mac LCIIs

and Mac 575s. There was one Macintosh 660AV machine in the technology coordinator's lab. Each lab had a laser printer. In addition, a special program that integrates technology into reading research had ten computers in the three classrooms that teach this program. All students participate in the program for one year. Each of the science rooms had three computers. No Internet access existed in the school.

As the descriptions demonstrate, each school varied on the types and amounts of computer technologies available to teachers and students. In each case, however, the schools consolidated the technologies in an attempt to provide the best access possible, given the numbers of computers available. Finally, only two schools had Internet access.

Teacher Descriptions. Bob (the teacher from School 1) is the physical education teacher who doubles as the computer resource teacher for his school. During the observation period, sixth grade students worked on creating a multimedia presentation. These students represented one half of their sixth grade class. Due to the small number of computers in this lab, the students rotate through the lab. At the end of this observation period, these students returned to class and the remaining students came to the computer lab to work on their projects. In neither case did the classroom teacher become involved in the students' activities in the lab. Bob actively helped the students open their folders and use the program. Two parent helpers were present, but unable to help, due to unfamiliarity with the program the students were using. Although some disparity of ability existed, all students were actively engaged in working on their project.

Eileen (the teacher from School 2), a third grade teacher, brought her students

into the basic lab promptly at 9:00 a.m. Each child immediately found a computer. Two additional adult volunteers were present. The students worked with the draw program of an integrated software package. Eileen demonstrated how to use the program to the students and then the students began working on their own. Unlike the parent volunteers for school 1, these volunteers helped Eileen actively address students' questions. The students attempted to draw an ogre and other pictures while learning the integrated program. The room was filled with laughter and activity as students moved around to look at others' pictures. They appeared to thoroughly enjoy the lab.

Sue (the teacher from School 3) is a first grade teacher. This teacher divided the class into four groups of six to eight students to facilitate using the three classroom computers. This observation period lasted 30 minutes because of a class assembly, therefore, only two groups used the computer this day. Sue sent one group to the computers while working with a reading group. The other two groups worked independently at their desks. The subject of this class period was seeds and plants. The program the students worked with was an interactive reading program on seeds and plants. All students were engaged and on task. The students using the computers paired up, started the program, and worked together answering the questions posed by the program. When the first group finished the program, the second group of students replaced them and worked cooperatively through the program. When they finished, these students shut down the computers and returned to their seats.

Nancy (the teacher from school 4) is a seventh-grade teacher and an award winner for the innovative use of technology. She teaches in a room with ten

computers that opens into the school library. She divided the class into groups and used technology to support several simultaneous activities. One group of three students rehearsed speeches written based on a research topic they had chosen. They were taking turns videotaping each other and watching the playback. A second group of five students was using a student word processor to add information and graphics to their individual research reports. Three students were looking through a CD-ROM for information on their topic. Other students were in various stages of gathering, organizing, and planning for their projects. Nancy coached students as they needed assistance. The entire program was designed to teach information selection, gathering, organizing, and sharing through the use of technology.

These teachers were remarkably similar. They demonstrated complete understanding of the software programs the students used. Bob, Eileen, and Nancy actively coached their students as necessary. Sue, on the other hand, worked with her reading groups while her computer groups worked at the computers. Periodically, she looked up to see how the students were doing on the computers, but did not interact with these students, except to instruct the second group to move to the computers at the appropriate time.

Interview Data

The interviews occurred after the observation periods. The interviews were audiotaped and transcribed verbatim for coding and analysis. The selected findings reported here address the research questions directly, while also providing more breadth to the classroom observations. Due to the small sample size and limited observations (each teacher was observed only once), we portray the teachers views

by presenting a narrative using their words.

Perceptions of the role of technology in the classroom. These teachers view technology as a tool to help them accomplish their jobs. In addition, these teachers believe technology motivates the students. As Bob stated, "I see it as a tool to help the teacher and help the students to learn. I see technology allowing kids to be more creative with their research. . . I think if you can give all kids from different backgrounds access to information, they are more willing to learn, and it makes learning more fun."

Teachers' perceptions of barriers they face in integrating technology into the classroom. These teachers feel a myriad of barriers block successful computer integration.

- Eileen felt *time*, *funding*, *limited internet access*, and *teachers' fear* represent the major barriers.
- Bob discussed the necessity of *community support* and *teacher acceptance*.
- Sue felt the largest barrier is the *rapid obsolescence* and the *necessity to replace hardware* and *software regularly.*
- Nancy felt *funding* is the major barrier to the successful implementation of technology in the classroom.

Teachers' perceptions of the kinds of support that exists for technology integration. Three of the teachers mentioned strong principal support which manifests itself in allocating funds for acquisition of hardware and software and for professional development. For example, Sue stated, "In the school, our principal is a former staff developer, so training is readily accessible all the time. We have a

CD-ROM course our principal has written and we have classes throughout the year, many of them involve technology because we have so much of it here. . . He's always willing to send us for training. For instance, he's sending me to a HyperStudio for Electronic Portfolio class this summer. . . If we said tomorrow we wanted training on such and such, it would be here. So we are fortunate here in our building." Nancy echoed this sentiment. She feels very fortunate to work in a school where there is such a priority placed on technology, but understands that she works in an unusual situation. Bob contrasted two previous principals, stating of one, "you couldn't get a dollar out of that guy. . . There was no money for technology." Eileen holds the same contempt for unsupportive administrators stating, "Administrators aren't supportive. It takes money, time, and training and administrators believe computer use in schools is a flash in the pan."

All teachers discussed the role of district support. Bob and Eileen, who incidentally teach in the same school district, discussed the need for visionary district-level leadership. They both lavished praise on the school district's technology director. Sue, on the other hand, felt that the district was not as supportive as it could be. In fact, this teacher contrasted school-level support with district-level stating, "I think in our building training is wonderful, in the district I'm not so positive."

Eileen felt that incentives are necessary and appropriate as a means to garner teacher support. She stated, " Here we have a group incentive plan and teacher performance pay tied to technology. The incentive plan is based on showing an effort and getting training. Other schools in the district have some type of incentive technology plan. I think that if the district really wants teachers to take classes that

are time consuming, yes the teachers should be rewarded." Bob corroborated that the school district offers an incentive plan and each school can tailor the plan as it sees fit.

Finally, Bob discussed the role that community support plays in integrating technology into the curriculum. The community from which this school draws its students is upper class and many of the parents use computers in their work. Bob believes that these factors contribute to the community's support for computers.

Teachers' perceptions of their skills. All four teachers report feeling comfortable with computers. Bob has always been interested in electronics and began working with computers when he taught school overseas for one year. This school had a computer lab and he began experimenting with computers there. This carried over into his present position when he returned to this school to teach. He has been the computer resource teacher in his school (the school does not have a separate full-time technology coordinator). Bob estimates he spends 20% of his time maintaining and repairing the computers, and teaching the teachers and students how to use the computers. When asked whether the school provided access to training, this teacher said he learned probably 90% of what he knows on his own and from a previous principal who taught him. He has not received any formal training. Bob stays current by attending monthly district computer resource teacher meetings held by the technology director, reading computer literature, and taking the present master's class. Finally, when asked to assess how well the school's teachers use technology, he provided an upbeat assessment.

> Most of our teachers use it all the time; 6th grade and 5th grade, 6th grade especially. I mean there are kids at the machines all day long in their rooms

because they are either doing research projects, integrated software projects, or they are doing stories for their classes. They are always in the lab doing stories. Some classes, like first grade, these teachers have no fear of their students on the computer, so they have kids on the computers all the time doing things, Kid Pix and creating things. The kindergarten teacher has no fear. We have kindergartners who are very adaptive in computers. I think overall, in the building we have a very computer literate staff.

As of the date of the interview, Eileen has been using computers for 9 years, trading up as computer technology continues to evolve. Although she feels she is not an expert and has a lot to learn, she states, "I'm comfortable in experimenting... I am not afraid to try things." She also is the computer resource teacher for her school. They had a part-time technology coordinator, but the funding ran out for that position. She believes other teachers in her building view her as being advanced because she is on the technology committee, has taught software classes at her school, and helps other teachers with computers when asked. She acknowledges that the school's teachers are at different levels when it comes to using and understanding computers, but feels the teaching staff is "higher than a lot." Eileen says she has a lot of experience because she pursued it and keeps current through the master's program, talking to other people involved in technology use, and reading about technology in professional journals.

Sue, who is in her second year of teaching, reports using computers throughout college for word processing. She feels very comfortable with software and running programs and wishes to learn more about computer networking. Sue uses the masters' degree program to stay current and spends time reading computer-

related literature. She sits on her school technology committee. When asked to assess the teachers in her school, she stated the following:

> We have teachers in our building who are over 60 and they're right on the cutting edge. If we are doing something new, they want to know how to do it and they're right in there with us. For personal use, they probably don't use it as much as I do. For personal use, they probably have their aides do their letters for home and that kind of thing. But use of it with kids, they're really right up there with us. We don't really have any teacher that totally resists using it. We have one teacher who is not into any skill and drill stuff, but she'll find the stuff in there that's not skill and drill and use it. And there's one teacher who is really into the arts and found in one of our programs, a thing for making movies, so that's what she did. But they were still using technology and integrating it into what they were doing. She was doing it through an artistic aspect. Which is neat because I think that's what everyone in our building does, they find their own little niche in techology and use that.

Nancy sees herself as a very skilled teacher and technology user. She recently received a second award for innovative use of technology. Nancy uses a wide range of software with her students and believes the other teachers view her as a technology leader among the staff.

She decided to enroll in this master's program to continue her growth in technology innovation. Nancy reports frustration concerning technology adoption and integration in her school. Only a small core group of teachers provides the impetus for forward movement of technology use in the building. Further, she estimates that while 30% of the teachers actually use technology, only about 10%

truly integrate it into their curricula.

How the labs are used. Each teacher was asked to provide a description of how the labs are used. According to Bob, School 1 uses its Apple IIe lab for drill and practice. "We use Minnesota Educational Consortium Curriculum and they have a lot of great programs for spelling, addition, subtraction, multiplication, fractions, stories, storybook, science, language arts. So if a kid is having a problem with say addition, a teacher can easily give him a disk and he can go to his IIe and work on addition facts or subtraction facts." The Apple IIgs lab is used for getting kids familiar with computers, drill and practice, and teaching keyboarding to the third and fourth grade students. The Macintosh lab is the multimedia lab used for publishing stories and using an integrated software package to create multimedia presentations. Fifth and sixth grade students use this lab.

The labs in School 2 are used in similar fashion. The fourth, fifth, and sixth grade students use the multimedia lab, although Eileen believes that lab is not used to its best capabilities since some of the teachers lack the knowledge, and the technology coordinator ran out of hours to provide assistance. The primary grades use the training lab almost exclusively.

The lab in School 3 is used by third through sixth grade students, although the school would like to accommodate first and second graders. The computer lab is used nonstop from 8:30 until 2:55 Monday through Thursday. Friday is set aside for sign up on an as needed basis. The software run in the lab is a computer-managed instruction package for math and reading. The library is used by all grades. Sue uses the library computers to reduce the number of students using her classroom computers to two students per computer, and also to use the CD-ROMs

for research. Grades three through six also go to the library to use a weekly multimedia news program. Finally, teachers and students use the library for Internet access.

The computer labs in School 4 are used to teach programs including basic computer skills, word processing, and HyperStudio to all seventh grade students. The majority of the work done in the labs is word processing.

Discussion and Conclusions

The purpose of this study was to examine: (a) teachers' attitudes toward integrating and using technology, (b) the barriers to technology use that exist for this group of teachers and how were they overcome, (c) how teachers actually use technology in the classroom, and (d) to determine what accounts for any differences between attitudes and intentions toward technology use.

Teachers' Attitudes

These teachers were interested in technology applications and had access to computers. We assumed they were serious about integrating technology into classroom practice and possessed favorable attitudes toward technology. Further, we believed these teacher held positive perceptions concerning their own technology skills.

The questionnaire and interview data confirms our assumptions. The Fishbein-Ajzen questionnaire demonstrated these teachers hold very favorable attitudes toward technology. Assuming the four teachers interviewed are typical of the group, the interview data confirms these teachers feel comfortable with computers and other technologies. They have invested considerable time learning how to use technology and staying current with technology applications. Using

Marcinkiewicz's (1993) levels of computer use, these teachers appear to be at least at the integration level, and perhaps the reorientation and evolution levels. At these levels, teachers fine tune technology use and adapt to change. Further, these teachers possess relatively high self-competence, a key motivator that contributes to computer use (Marcinkiewicz, 1993). These teachers appear to be innovators (Rogers, 1995).

Barriers to Technology Integration

Funding, time, and access appeared to be the dominant barriers to technology integration these teachers face. Overwhelmingly, the teachers discussed the necessity for adequate funding to purchase hardware and software and pay for professional development. Thus funding impacts both the quantity and quality of technologies available (access) and the ability to use the technology.

Access means more than simply making the technology available. It involves placing the right types of technology, in the right amounts, for teachers and students to use. In other words, access requires connectivity, ubiquity, and interconnectivity (Jones, Valdez, Nowakowski, & Rasmussen, 1994) if technology is going to impact the educational process in a positive manner. Although all four schools provide CD-ROM databases for teacher and students use and Schools 2 and 3 provide limited Internet access, they provide, at best, marginal connectivity (based on the earlier definition). Given the types and amounts of technologies possessed by these schools, they arguably provide access to everyone in the school. Schools 1 and 2 use computer labs to create a critical mass of computers for teacher and student use. Schools 3 and 4, on the other hand, differentially distribute computers between classrooms and computer labs to place the technology

where it will most efficiently and effectively be used. These allocation strategies fit the strategies Means and Olson (1995) found schools use when quantity is not sufficient for effective distribution to all classrooms. Finally, none of these computers are networked to facilitate interconnectivity among the teachers and students.

Each teacher interviewed had considerable personal experience outside of school with technology. This translated into an approach to computer use that does not reside in most teachers. In each case, if professional development was available to the teachers, the principals either supplied the money for outside training, or in the case of Bob and Sue, the mentorship for school level training. However, the investment in staff development and on-site teacher support appear inadequate. It seems that these schools and school districts rely primarily on the initiative of the teachers to obtain training.

<u>Actual Technology Use</u>

Consistent with the methods for allocating limited technologies, these schools and teachers have made value judgments concerning appropriate technology uses based on the grade level and maturity of the students. For example, the multimedia labs in Schools 1 and 2 and the lab in School 3 are designated for the higher grade levels and use for projects and other interactive activities. The basic labs in Schools 1 and 2 are designated for basic drill and practice work for the lower grades. Sue uses primarily her classroom computers, and supplements, as necessary, by using the library computers. For the three elementary schools then, as students progress in grade level, they gain access to the newer, more capable machines. The computer labs in School 4 are used exclusively by the seventh graders, primarily

for word processing.

As a physical education teacher, Bob uses video technologies during class. However, he devotes a considerable portion of his day to his duties as computer resource teacher. In this role, he repairs and maintains the computers, trains teachers how to use the school's computers, and facilitates student activities in the multimedia lab.

Eileen does not use the computer labs more often than other third grade teachers, but she believes she uses the labs more extensively. For example, she states that rather than have the students use the computers to import pictures into stories they write, she wants them to learn to draw their own pictures. She reports that she integrates computer-based activities into her curriculum. For example, Eileen stated:

> We did a family photo project that was social studies. The kids took pictures and we put them on a photo CD at the end of the year. Then we created stories about our families. This was a social studies project, but I incorporated technology with it.

Sue reports using computers as a "center type activity, where I try to correlate it with what we are doing, whether it would be reading, or writing, or math." During the observation period, this teacher's students worked cooperatively with an interactive reading program on seeds and plants.

Nancy uses technology to support her classroom activities. She promotes an active, collaborative environment where the students rely on one-another as much as they do on her to accomplish their tasks.

Clearly these teachers incorporate technology into their curriculum in grade-

appropriate and innovative ways. Apple Computer, Inc. (1995) has identified five technology adoption phases and these teachers appear to fall into the latter two categories — appropriation and invention. These teachers focus on cooperative, project-based work, incorporate technology as needed, and use technology as one of many tools. They also design new uses for technology.

Do Differences Exist Between Attitudes, Intentions, and Use?

The Fishbein-Ajzen questionnaire results indicate a difference exists between intentions to use specific types of technologies and actual use. In particular, the teachers in this study indicated that they do not use interactive video, the Internet, the World-Wide Web, and on-line data bases. We would suggest that the lack of adequate access likely accounts for the low use of these technologies. The cost of using these technologies is also a deterrent, as well as policies which regulate their use.

We recommend access to technology and policies that encourage its use as a way to begin integration. However, they are not sufficient. Time and cost will be ongoing barriers that will always need to be addressed.

References

Apple Computer, Inc. (1995). Changing the conversation about teaching, learning, and technology: A report on 10 years of ACOT research. Cupertino, CA: Apple Computer, Inc.

Eagly, A. H., & Chaiken, S. (1992). The psychology of attitudes. San Diego, CA: Harcourt Brace Jovanovich.

Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1994). Designing learning and technology for educational reform. North Central Regional Educational Laboratory.

Marcinkiewicz, H. R. (1993). Computers and teachers: Factors influencing computer use in the classroom. Journal of Research on Computing in Education, 26(2), 220-237.

Means, B, & Olson, K. (1995). Restructuring schools with technology: Challenges and strategies. SRI International.

Rogers, E.M. (1995). Diffusion of innovations (4th ed.). New York: The Free Press.

U.S. Congress, Office of Technology Assessment. (1995). Teachers and technology: Making the connection. (OTA-EHR-616). Washington, DC: U.S. Government Printing Office.

Walster, D. (1994). Applying an attitude-behavior consistency model to research in library and information science. **LISR 16**, 157-172.

1996 National Education Summit Policy Statement. [On-line]. Available: http://www.summit96.ibm.com/brief/finaledpol.html

Table 1

General Attitudes Toward Technology

Question	Mean (Range +3 to -3)[1]	Standard Deviation
Using technology in the classroom is important	2.36	.49
Using technology in the classroom is wise	2.27	.55
Using technology in the classroom is beneficial	2.27	.70
Using technology in the classroom is good	1.91	1.10
Generally speaking, I want to do what most people think I should do	.43	1.30

[1] Higher numbers indicate a more positive attitude.

Table 2

General Intent to Use Technology

Question	Mean (Range 0 to 3)[1]	Standard Deviation
When I am teaching in the classroom I intend to use technology	2.19	.68

[1] Higher numbers indicate more frequent use.

Table 3

Attitudes, Intentions, and Behaviors Toward Technologies

Instructional Technology	Attitude Toward Instructional Technologies (Range +3 to -3)[1]		Intention Toward Instructional Technologies (Range 0 to 3)[2]		Behavior Toward Instructional Technologies (Range 0 to 3)[2]	
	Mean	SD	Mean	SD	Mean	SD
Prerecorded Video	1.91	.97	1.32	.72	1.36	1.00
CD-ROM	2.14	.89	1.77	.87	1.18	1.20
Interactive Video	1.68	1.20	1.19	.81	.36	.66
Computer Graphics	2.09	.81	1.73	.77	1.27	.88
Telecommunication	2.00	.69	1.67	.97	1.05	1.10
Hypermedia	1.64	1.30	1.65	1.10	.77	1.00
Video Cameras	1.82	1.10	1.46	.80	1.05	.90
World Wide Web	1.77	.92	1.18	.85	.32	.65
On-line Data Bases	1.38	.97	1.00	.75	.36	.66
Internet	1.77	.81	1.38	.92	.38	.74
E-mail	1.73	1.10	1.36	.90	1.14	1.30
Multimedia	2.27	.83	1.81	.87	1.27	.99
Overheads	1.43	1.30	1.71	1.10	1.62	1.20
Tape Recorders	1.30	1.10	1.19	.93	.77	1.10
Electronic Card Catalog	1.86	1.20	1.33	1.00	.91	1.20
New Technologies	2.57	.60	2.18	.85	1.36	.90

[1] Higher numbers indicate a more positive attitude.
[2] Higher numbers indicate more frequent use.

Figure Caption

Figure 1: Sample General Attitude and Intention Questions

Using instructional technologies in the classroom is								
Important	______	______	______	______	______	______	______	Unimportant
	Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely	
When I am teaching in the classroom I intend to use instructional technologies								
______ Frequently	______ Fairly often	______ Sometimes	______ Never					

Figure Caption

Figure 2: Sample Attitude, Intention, and Behavior Toward Specific Technologies Questions

My attitude toward **prerecorded video** (e.g. videodiscs and videotapes) in the classroom is

Favorable	______	______	______	______	______	______	______	Unfavorable
	Extremely	Quite	Slightly	Neither	Slightly	Quite	Extremely	

When I am teaching in the classroom I intend to use **prerecorded video**

______ Frequently ______ Fairly often ______ Sometimes ______ Never

I used **prerecorded video**

______ Frequently ______ Fairly often ______ Sometimes ______ Never

The US WEST Foundation

Teacher Network Project

Final Evaluation Report

Nancy M. Sanders, Ph.D.

With
Ravay Snow-Renner
John Higgs
Lynn Miller

March 18, 1997

Colorado Education Policy Consortium
University of Colorado, Denver
Campus Box 193
P.O. Box 173364
Denver, CO 80217-3364

Section V

Review of National Literature on Technology in Education:

Focus on Telecommunications

Nancy M. Sanders
John Higgs
Lynn Miller

We conducted a computer search of publications about telecommunications using ERIC, the Education Resources Information Center on-line library database and reviewed other sources and bibliographies from major reports. ERIC is a computerized listing of all articles, reports, projects, dissertations and books. Keywords or descriptors enable users to conduct targeted searches of the huge database. We looked for reviews of research on technology, surveys of technology use and availability, and telecommunications projects. The keyword *computer* (in the field of education) produces more than 4,000 entries. In order to focus and narrow the search, we used *computers*, *technology*, *telecommunications*, *training*, and *schools* as keywords that produced 40 entries since 1993 to compare with the Teacher Network Project, of which we were able to locate 37. (The remaining three articles were about information technology ethics, microcomputer course characteristics, and training day care providers in telecommunications.)

This literature review is categorized into four types of information that we obtained through our search: <u>research/advocacy</u> (why use technology?); <u>reviews of research about the effects of technology with a focus on telecommunications</u>; <u>national surveys about technology and telecommunications use, availability and access</u>; and <u>reports on projects comparable to the</u>

Teacher Network Project.. Each of these is described in turn.

Telecommunications: Definitions

Telecommunications technologies are defined as tools which transmit voice, video, or data signals, either through a wire or the electromagnetic spectrum (Council of Chief State School Officers, 1995). These tools include broadcasting, satellite, cable, telephone, microwave/ITFS, wireless, and computer networks (Council of Chief State School Officers, 1995; Moore & Thompson, 1990). Learning applications of telecommunications technologies mainly consist of "(1) video instruction (one-way video and two-way audio and two way video/audio); (2) information retrieval from databases/libraries; (3) two-way asynchronous applications such as e-mail, listservs, bulletin boards, news groups; (4) electronic transfer of instructional software and simulations; and (5) distance learning" (Weisburg & Ullmer, 1995, p. 636).

I. Advocacy: Why use technology in schools?

This literature describes three basic reasons for increasing use of technology in schools: the importance of technology in modern society; the potential for reforming classroom practice and teaching; and the evidence that technology leads to higher achievement (described in the section on reviews of research).

First, technology is ubiquitous to society. The Benton Foundation (1995) reports that "advanced telecommunications technologies are increasingly shaping how we work, play, and relate to one another." For example, 75% of Americans work in service and information jobs, with almost

50% of the employed population working in jobs requiring computer use (double the rate of just 10 years ago). By the year 2000, it is estimated that the number of jobs requiring information technologies skills will increase to 60% of the workforce (Benton Foundation, 1995). As information technologies continue to proliferate and societal change accelerates, students graduating from high school and college today can expect to switch jobs up to six to eight times over the course of their working lives. Not only are information technology skills needed in the workplace, they are increasingly employed at home; the Department of Labor (as cited by the Benton Foundation, 1995) estimated that 37% of American households have computers and expects continued growth as computers become more affordable.

Second, technology can support a variety of educational approaches but possesses the potential to reform education. Technology has been used predominantly to reinforce traditional teaching methods (rote learning and skill and drill practice). Many technology advocates criticize this use of technology because it perpetuates an education system that is not sufficient to meet the needs of the 21st century. For example, Grabinger (1996) believes that this system of education produces students who "treat information as facts to be memorized and recited rather than as tools to solve problem relevant to their own needs" (p.2). This process results in creating inert knowledge, which is information memorized devoid of context that may be relevant to new situations, but not transferable (Grabinger, 1996; Perkins, 1991; Bransford & Vye, 1989; Whitehead, 1929). Decontextualized learning results in learners unable to recall and transfer knowledge and skills to new and novel situations, the exact opposite of the skills education scholars believe are necessary to function in the 21st century. In other words, teaching centered

on lower-order thinking skills, whether done by a teacher or technology, does not develop the critical-thinking skills that allow people to fully participate in the modern information-age society (Grabinger, 1996).

Technology can support development of a learner-centered environment that emphasizes critical-thinking skills acquisition. Collins (1991) identified the following trends in schools that have adopted computers:

(1) a shift from a whole-class, teacher centered learning environment to small-group instruction;

(2) a shift in the teachers' role from lecturer to coach and facilitator;

(3) a shift from working primarily with better students to working with weaker students;

(4) a shift to more engaged and motivated students;

(5) a shift from assessment based on quantity of knowledge to product-based assessment that measures retention, understanding, and active use of the knowledge;

(6) a shift to a cooperative social learning structure from a competitive structure;

(7) a shift toward individualized education in which, rather than all students learn (memorize) the same things, students learn different things; and

(8) a shift toward integrating visual and verbal thinking.

These trends reflect a learning environment that is experiential and activity-based (Dewey, 1938) "in which a student can 'master new knowledge and skills, critically examine assumptions and beliefs, and engage in an invigoration, collaborative quest for wisdom and personnel, holistic development'" (Jonassen, et al., 1995, p.7). This environment produces critical thinkers who are

able to frame and solve ill-defined problems in an information-rich world. This technology not only possesses the ability to provide the valuable life skills to American students but also the potential to transform education.

As the 1996 National Education Summit attendees proclaim, "We are convinced that technology...can be utilized as a helpful tool to assist student learning, provide access to valuable information and insure a competitive edge for our workforce" (1996 National Education Summit Policy Statement, p.2). Integrating technology into the classroom "substantially improve(s) access to the best instructional methods and materials for all students" and "provide(s) students with the hands-on experience to develop the knowledge and skills they will need to compete successfully in the workplace" (1996 National Education Summit Policy Statement, p.3).

<u>The third and final reason for advocating technology in schools is a limited but growing body of research indicating that technology can positively impact student achievement and attitudes</u>. This research has been summarized through published reviews of research about the effects of technology, described below.

II. Reviews of Research about the Effects of Technology

Meta-analysis is a method of assessing the statistical results from many different studies into a single finding by calculating effect size (Krathwohl, 1993). Effect size is a score in standard deviation units; an effect size of 0.3 means that the average person in the treatment group performs about 0.3 standard deviations better than the average person in the control group. Kulik

and Kulik (1991) performed a meta-analysis of 254 studies examining the effects of computer-based instruction for kindergarten students through the college level and found an effect size of 0.3. These results have been corroborated by other researchers as well. For example, Sivin-Kachala and Bialo (1994;1996) provide a summary of several meta-analyses demonstrating effect sizes ranging from 0.27 to 0.50. Sivin-Kachala and Bialo conclude that "these meta-analyses confirm that technology has a positive effect on student achievement."

Interactive Educational Systems Design (1994;1996), an independent consulting firm, contracted with the Software Publishers Association to perform an analysis of the effectiveness of technology in schools. One-hundred and thirty-three (1994) and one-hundred and seventy-six (1996) research reviews and reports formed the basis of these analyses respectively. Analytical techniques included meta-analysis, direct comparisons of technology use to traditional instructional methods, comparisons of different software designs or the use of technology under different learning environment conditions, classroom observations, and surveys. In both instances the reports conclude that "technology is making a significant positive impact in education" (p.2). Important findings include:

(1) positive effects exist throughout education (preschool through higher education), for both regular and special needs students in all major subject areas;

(2) technology positively affects students' attitudes toward learning and self-concept; and

(3) technology introduction enhances cooperation and collaboration, increasing teacher-student and student-student interactions.

Two long-term examples of technology impact are frequently cited in the literature. The Apple Classrooms of Tomorrow (Apple Classrooms of Tomorrow Advanced Technology Group, 1995) was started in 1985 to explore what happens to students and teachers when they have access to computers whenever they need it. Apple Computers, Inc. supplied computers and trained teachers at two sites initially, adding more sites and teachers over the years. Dwyer (1994, p.4) reports that "After nearly eight years of studying the effects on classrooms, ACOT researchers have observed profound changes in the nature of instruction, learning, assessment, and the school culture itself." Comprehensive ACOT research demonstrates that technology significantly increases the potential for learning, "especially when it is used to support collaboration, information access, and the expression and representation of students' thoughts and ideas" (p.24).

The CHILD (Computers Helping Instruction and Learning Development) study, which started in 1987, investigated the impact of computer use on more than 1,400 students and their teachers from nine Florida elementary schools (Kromhout & Butzin, 1993). Each participating teacher received technical training with the computers as well as training emphasizing a team approach with other participating teachers. Three to six computers were placed in each participating classroom and curriculum and computers were integrated. Results of the study showed positive and statistically significant standardized test scores for all participating grades and schools; the largest effects appeared for students involved in the program for more than one year. At the conclusion of the study in 1992, none of the schools expressed dissatisfaction with the project; in fact, five schools planned to expand their level of participation, and nine new schools were about to join CHILD (Kromhout & Butzin, 1993).

Telecommunications and Student Achievement

Unfortunately, much less empirical study has been conducted in the area of telecommunication networking and student achievement. Moore and Thompson (1990) conducted an exhaustive literature review of the effects of interactive technologies on achievement in K-12 education and found the literature scarce, and mainly consisting of "case studies, opinions, and advice" (p.7). Sivin-Kachala and Bialo (1996) reviewed the research on the effects of telecommunications in the areas of student achievement, student attitudes, and student-teacher interactions. They too found the literature limited to a handful of studies. The following summarizes this research:

(1) **Telecommunications and achievement.** Three studies researching the use of networking for collaboration between classrooms in different geographic areas demonstrate:

(1) increased writing skills for less socially oriented and academically skilled students, and

(2) a significant improvement in use of graphs, data interpretation skills, and geographic knowledge.

(2) **Telecommunications and student attitudes.** Two studies looking at the impact of telecommunications on student attitudes found that courses featuring telecommunications and collaboration positively affected students interest, motivation, and attitudes toward learning.

(3) **Telecommunications and student-teacher interactions.** Two studies focused on telecommunication's effects on teacher-student interactions in college found that amount and quality of interaction increased outside of class without decreasing standard forms of

communication. Teachers also focused their attention more on lower-performing students, in contrast to the focus on higher-performing students in conventional classrooms.

III. Survey Findings about Technology Access and Use.

The Congressional Office of Technology Assessment (1995) reports that three major barriers include access, funding, and professional development.

Access. In 1995, schools in the United States had 5.8 million computers, about one for every nine students. About half of the computers are older, 8 bit machines that cannot use CD-ROMs, networks, or complex software. Seventy-five percent of schools have either LAN or WAN access. However, only one teacher in eight has a telephone in the classroom, and less than one teacher in 100 has direct access to a computer network. Thirty-five percent of public schools have access to the Internet but only 3% of classrooms have access. Most computers with network access are used for administrative purposes and 71% of computers with Internet access are in administrators' offices. Location and access are critical factors in use. Teacher and student schedules and the limited size of computer labs make it difficult for students and teachers to use telecommunications. When there are more students in a class than there are computers, teachers have difficulty managing activities and access.

Although 5.8 million computers provides a nine to one student-to-computer ratio, tremendous variability exists in computer-student ratios from school-to-school. The Benton Foundation

(1995), a nonprofit telecommunications advocacy agency, reports that unequal access represents the biggest concern in connecting the nation's classrooms. Larger school districts and those with larger budgets have more and better technology resources. The US Department of Education's Office of Educational Research and Improvement reported in 1993 that telecommunication users come from schools that have more than double the national average of computer hardware.

Further impeding the effective use of computers and telecommunications networking is the education system's penchant for locating computers primarily in computer labs (one-half of all computers are located in centralized labs) instead of classrooms, where only 35% are situated. Centrally located computers discourage teacher use. Finally, the large supply of outdated equipment, coupled with very limited telecommunications links (telephone lines, modems, and Internet access) inhibits schools from fully participating in the opportunities presented by telecommunications networks.

Funding. Estimates for installing and operating telecommunications technologies vary tremendously. For example, one-time installation costs (initial training included) range from $80 million (for one computer per school connected to the Internet though a school district server) to $145 billion (one computer per student desktop, connected to the Internet). Estimated annual operating costs for these configurations (including annual teacher training and support) range from $160 million to $11.3 billion.

Professional development and training. The majority of school teachers feel inadequately trained to use computer-based technologies. On average, school districts devote no more than 15% of their technology budget for teacher training and this focuses primarily on operating the equipment, not how to integrate the technology into the curriculum. Further, onsite support is almost nonexistent. For example, only 6% of elementary schools and 3% of secondary schools employ full-time technology coordinators, while fully 60% of schools do not have anyone assigned to technology coordination and support. Finally, teachers simply lack the time necessary to experiment with and learn how to use technology effectively.

U.S. businesses reportedly spend at least $50 billion a year to train employees, and 30% of this is spent on computer-aided instruction. The OTA reports that less than one-third of all teachers have had more than ten hours of computer and technology instruction. On average, districts spend 15% of their technology budgets for training and the rest is hardware (55%) and software (30%). Finally, once training is completed, there is very little technical support, leading to user frustration. Teachers often report discouragement with technology use after initial training due to the lack of follow-up support. Without time, training, and technical support, teachers are unlikely to incorporate technology into their teaching. One author estimated that it takes between five and six years for teachers to master the use of computers and use technology successfully in teaching.

Additional barriers. Southwest Educational Development Laboratory (1995) conducted a study to determine the status of telecommunications networking in public education in the

United States. Representatives, staff personnel responsible for telecommunications networking within the state department of education from 46 of the 50 states, as well as Puerto Rico and the U.S. Bureau of Indian Affairs, responded to a survey concerning the status of telecommunications networks for public schools in their areas. Funding emerged as the overwhelming problem. Other significant barriers that emerged include technical infrastructure and support, legislative and regulatory actions, professional development and training, educational system and policy barriers, lack of equitable access to network technologies, lack of skilled personnel to deploy and service school networks, and inadequate and outdated technology in local, rural telephone companies.

IV. Reports on Projects Comparable to the Teacher Network Project.

We located 37 reports related to telecommunications projects in education since 1993. The reports provide limited and inconsistent details about specifics like length of project, equipment provided, source of funding, numbers of educators trained, and technical support (e.g., Orwig, 1994). Most of the projects were small scale, with either a few teachers or a small number of schools. There were four telecommunications projects of over 100 teachers, and only one indicated the source of funding. The Nebraska Department of Education (Pawloski, 1994) provided Internet access to 3,000 teachers in 1993-94. The state was described as currently levying local taxes to provide Internet training and access to all 20,000 teachers. Another project enabled 3,000 teachers in Houston to lease computers for $1 per year with training, but few other details were provided (Orwig, 1994). A two-year project provided 932 teachers with training in technology and telecommunications software, using on-line projects and contests (Bos, et al,

1995). Seventy-eight percent of the teachers said that the training changed their teaching styles, and 56% said they collaborated with one or more other teachers through a network. Duration of training varied greatly, from 24 hours total to 16 weeks of a telecourse. One project provided computers and a 70 hour training (Orwig, 1994). The National Science Foundation trained 32 high school science teachers in a two-week institute, focusing on telecommunications for continued interaction with a loss of four participants over a year (Caggiano, 1995).

Summary and Conclusions

The vast amount of research has focused on technology or computers as generic categories. However, since telecommunication networks (as defined earlier) rely on computers, the limited research conducted into telecommunications appears to parallel and duplicate these findings. Given this similarity, educators, policymakers, and business leaders believe that technology, especially telecommunications technologies, is critical to educate students for the modern world, possesses the potential to transform educational practice, and has a proven track record of increasing achievement.

The literature strongly advocates the position that telecommunications provide the means for storing, accessing, creating, delivering, and evaluating enormous amounts of information. Further, when available and integrated into the curriculum, telecommunications technologies, especially networked telecommunications, can change the learning environment from a teacher-dominated environment, in which learners rely almost exclusively on teachers to disseminate information, to a learner-centered environment in which students become active, responsible

participants and teachers become facilitators and managers of student learning. This type of environment promotes the ability to learn how to learn, which, given the changes taking place in society, best prepares today's students for an information-based society requiring flexible, highly skilled workers (Weisburg & Ullmer, 1995)

From this review of the literature, we conclude that the Teacher Network Project:

- targets the most important issues identified in the literature on technology in education,
- is among the largest education-related telecommunications projects in the country,
- provides more resources and technical support than almost all other projects reported, and
- has among the most comprehensive evaluation and staff follow-up to monitor progress on clearly specified goals of any project in the literature on telecommunications in education.
- is among the most extensively documented and successful large-scale projects for K-12 teachers.

References

Apple Classrooms of Tomorrow Advanced Technology Group, Apple Computer, Inc. (1995). Changing the conversation about teaching, learning, and technology: A report on 10 years of ACOT research. Cupertino, CA: Author.

Aronin, G. (1992). Preparing teachers for a shrinking world. Northeastern Illinois University. (ERIC Document Reproduction Service No. ED 351 319)

Baker, E.L. & O'Neil, H.F. (1994). Technology assessment in education and training. Hillsdale, NJ: Lawrence Erlbaum Associates Publishers.

Becker, H.J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. Journal of Research on Computing in Education, 26(3), 291-321.

Benton Foundation (1995, September). Communications policy project: The learning connection. [On-line]. Available: http://www.benton.org/cgi-in/lite/Goingon/learning.html

Boone, W.J., Bennett, C. & Ovando, C. (1995). Teachers'' attitudes toward distance learning technology in a science/society global issues course. Journal of Computers in Mathematics and Science Teaching, 14 (3), 305-323.

Bos, N.D., Krajcik, J.S., & Patrick, H. (1995). Telecommunications for teachers: Supporting reflection and collaboration among teaching professionals. Journal of Computers in Mathematics and Science Teaching, 14(1/2), 187-202.

Bransford, J.D., & Vye, N.J. (1989). A perspective on cognitive research and its implications for instruction. In L.V. Resnick & L.E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (p. 173-205). Alexandria, VA: ASCD.

Caggiano, M.E., Audet, R.H. & Abegg, G. (1995, April). A pilot study of an electronic community of interdisciplinary secondary science teachers. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA. (ERIC Document Reproduction Service No. ED 382 473).

Chan, T. (December, 1993). Proceedings of the 1993 International Conference on Computers in Education. Ministry of Education, Taiwan, R.O.C.

Collins, A. (1991). The role of computer technology in restructuring schools. Phi Delta Kappan, 28-36.

Conte, A.E. (1995). Is it possible to integrate mathematics, science, and technology?

Kappa Delta Pi Record, 32 (1), 34-36.

Council of Chief State School Officers (1995). Distance learning for all learners. United States education and instruction through telecommunications. Washington D.C.: National Telecommunications and Information Administration. (ERIC Document Reproduction Service No. ED 384 343).

Dewey, J. (1938). Experience and education. New York: Collier Books.

DiMauro, V. & Jacobs, G. (1995). Collaborative electronic network building. Journal of Computers in Mathematics and Science Technology 14 1/2, 119-131.

Dwyer, D. C. (1994). Apple classrooms of tomorrow: What we've learned. Educational Leadership, 51, 4-10.

Finkel, L. (1991). Technology tools in the information age classroom. Wilsonville, OR: Franklin, Beedle & Associates.

Fullan, M. (1991). The new meaning of educational change. New York: Teachers College Press.

Gilder, G. (1993). The information revolution. The Executive Educator, 15 (3), 16-19.

Gottlieb, A. (1995, January 30). Hope for data democracy fades: Internet another white male bastion. The Denver Post.

Gottlieb, A. (1995, January 31). Leaping into the 'net: Books, experts will get you connected. The Denver Post.

Grabinger, R.S. (1996). Rich environments for active learning. In D.H. Jonassen (Ed.), Handbook on instructional technology research. New York: Scholastic Press.

Grandgenett, N.& Harris, J. (1994). Factors associated with intensive telecomputing use among teachers. Journal of Technology and Teacher Education, 2 (1), 3-16.

Heaviside, S., Farris, E., Malitz, G., & Carpenter, J. (1995). Advanced telecommunications in U.S. public schools, K-12. U.S. Dept. of Education, Office of Educational Research and Improvement. NCES 95-731.

Hedberg, J.G. & Harper, B. (1993). Supporting and developing teachers through telecommunications. Education Media International, 30 (2), 88-93.

Honey, M. & Henriquez, A. (1993). Telecommunications and K-12 educators: Findings

from a national survey. Center for Technology in Education. New York. Office of Educational Research and Improvement (ED), Washington, DC. 2-93. (ERIC Document Reproduction Service No. ED 359 923)

Hurst, D.S. (1994). Teaching technology to teachers. Educational Leadership,51 (7), 74.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B.B. (1995). Constructivism and computer-mediated communication in distance learning. The American Journal of Distance Education, 9 (2), 7-26.

Knapczyk, D. & Rodes, P. (1995). Effecting change in in-service teachers through distance education and communication technology. Journal of Technology and Teacher Education, 3 (1), 47-55.

Krathwohl, D.R. (1993). Methods of educational and social science research: An integrated approach. White Plains, NY: Longman.

Kromhout, O., & Butzin, M. (1993). Integrating computers into the elementary school curriculum. Journal of Research on Computing in Education, 26 (1)

Kulik, C.C., & Kulik, J. (1991). Effectiveness of computer-based instruction: An updated analysis. Computers in Human Behavior. 7 (12), 75-94.

Lewis, P. (1995, November 5). An internet survey - with credibility. The Denver Post.

Lucas, C. & Lucas, L. (1995). What works in educational technology. Denton, TX: University of North Texas, College of Education.

Marcinkiewicz, H.R. (1993-94). Computers and teachers: Factors influencing computer use in the classroom. Journal of Research on Computing in Education, 26 (2), 220-237.

Means, B., Olson, K., & Singh, R. (1995). Beyond the classroom: Restructuring schools with technology. Phi Delta Kappan. Sept. '95, 69-72.

Moore, M., & Thompson, M. (1990). The effects of distance learning: A summary of literature. Research monograph no. 2. Southeastern Ohio Telecommunications Consortium. (ERIC Document Reproduction Service No. ED 330 321).

Murfin, B. (1995, April). A survey of telecommunications use by secondary school science teachers in New York City. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA. (ERIC Document Reproduction Service No. ED 381 400).

Office of Technology Assessment (OTA). (1995, April). Teachers and technology: Making the connection, OTA-EHR-616 (Washington, DC: US Government Printing Office).

Orwig, A. (1994). Begin with teachers and watch students benefit. Technology and Learning, September 1994, 74-76.

Patton, M.Q. (1990). Qualitative evaluation and research methods. London: Sage Publications.

Pawloski, B. (1994). How I found out about the internet. Educational Leadership, 51 (7), 69-73.

Perkins, D.N. (1991), Technology meets constructivism: Do they make a great marriage? Educational Technology, 31 (5), 18-23.

Plotnikoff, D. (1994, August 30). Women drivers sparse on information superhighway. The Denver Post.

Poll: Internet snags general population (1995, October 31). The Denver Post.

Prancan, J. (1996, February 24). Teaching kids their a, b, c, d, e-mail. The Denver Post.

Purdum, T.S. (1996, March 10). Clinton gets classes onto the internet. The Denver Post.

Quality Education Data and Malarkey-Taylor Associates. (1995). Education technology survey. (Commissioned by the National Education Association, National Association of Secondary School Principals, National Association of Elementary School Principals, American Association of School Administrators, and Cable in the Classroom).

Ritchie, D., & Wilburg, K. (1994). Educational variables influencing technology integration. Journal of Teacher Education, 2(2), 143-153.

Ruopp, R., Gal, S., Drayton, D., & Pfister, M. (1993). LabNet: Toward a community of practice. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Sivin-Kachala, J., & Bialo, E. (1996). Report on the effectiveness of technology in schools, '95-'96. (Software Publishers Association). Washington D.C.

Serju, T. (1996). Conquering cyberphobia can open up new worlds. The Denver Post.

Sheingold, K., & Hadley, M. (1990, September). Accomplished teachers: Integrating computers into classroom practice. Center for Technology in Education, New York.

Sivin-Kachala, J., & Bialo, E. (1994). Report on the effectiveness of technology in schools, 1990-1994. Washington D.C.: Software Publishers Association, (ERIC Document Reproduction Service No. ED 371 726).

Snyder, T. (1994). Computers: Ready or not, here they come! The Education Digest, September, 25-28.

Software companies court girls. (1994, November 13). The Denver Post.

Stout, C. (1995). Networks for Goals 2000 reform: Bringing the Internet to K-12 schools. Austin, TX: Southwest Educational Development Laboratory.

Stuhlmann, J. (1994). Telecommunications and teaching practices: What lead to change? Journal of Information Technology for Teacher Education, 3 (2), 199-211.

Telecommunications and teachers: Preliminary findings from a national survey (1993). News from the Center for Children and Technology and the Center for Technology in Education,2 (2), 2-9. (ERIC Document Reproduction Service No. ED 364 250).

Thompson, M.S., & Blanton, W.E. (1993). Evaluation research on telecommunications applications in teacher education. Technology and Teacher Education Annual. 713-715. (ERIC Document Reproduction Service No. ED 355 937).

Weisburg, M., & Ullmer, E. (1995). Distance learning revisited: Life-long learning and the national information infrastructure. Proceedings of the 1995 Annual National Convention of the Association for Educational Communication and Technology, Anaheim, CA, 17, 628-647.

Werner, J. (1994, March). Reaching out to the world: Training teachers to integrate telecommunications into special education classrooms. Paper presented to Annual National Conference of the American Council on Rural Special Education, Austin, TX.

Whitehead, B.M., Cain, K.C., & Graves, G. (1994). Put computers into elementary classrooms - not labs! The Education Digest, December 1994, 16-19.

Wilson, B., & Peterson, K. (1991). Successful technology integration in an elementary school: A case study. Technology Integration: Case Studies, 201-274.

Zeiger, D. (1995, July 17). Software blocks unwanted 'net content. The Denver Post.

Zeiger, D. (1995, July 17). Vigilant parents are kids' best protection from online trouble. The Denver Post.

Zeiger, D. (1995, September 11). Homework online offers resources, risks. The Denver

Post.

Zeiger, D. (1996, June 1). Colorado high on PC's: 51% of state's households own computers, poll finds. The Denver Post.

Zeiger, D. (1996, June 17). Schools fall far short when it comes to technology. The Denver Post.

1996 National Education Summit Policy Statement. [On-line]. Available: http://www.summit96.ibm.com/brief/finaledpol.html

Technology's Role in Educational Reform

A Plan for Technology Adoption

By: John Higgs

For: Drs. Nancy Sanders and Bob Palaich

Class: EDUC 7250 The Nature of Work in Schools
University of Colorado at Denver

Date: November 11, 1996

Introduction

In the turbulent world today, the relentless march of time toward the 21st century represents the only constant. As humankind approaches the year 2000, the world is entering into another period of revolutionary change, moving from the Industrial Age to the Information Age. The technological revolution driving the change engine permeates throughout society, from how we accomplish our jobs to how we enjoy our leisure activities; unfortunately one facet of society, to a large degree, has been bypassed by the technological juggernaut--education. Public education in the United States still closely resembles the model of education developed to usher in the industrial revolution almost a century ago. This paper argues that education must incorporate the teaching practices and technology necessary to improve and transform education; furthermore this paper advances a plan to accomplish this integration.

Need for Change

Reform

The National Commission on Excellence in Education concluded in *A Nation at Risk* (1983) that "the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a nation and a people" (p. 5). Concluding that the United States is significantly disadvantaged in the world economy, this report ushered in a multitude of education reform proposals (the Secretary's Commission on Achieving Necessary Skills [SCANS], Goals 2000, and the report of the National Council on Education Standards and Testing [NCEST]) which link education and employment through curriculum and assessment to overcome these disadvantages (Pullin, 1994). Additional efforts to improve student performance center on the school choice and back-to-basics movements. These efforts attempt to standardize

curriculum and evaluation measures, but unfortunately they also tend to perpetuate the historic look and feel of education.

While concern exists that the education system is not producing capable students (based on falling standardized test scores when compared to other countries) a growing consensus exists that the traditional model of teaching and learning is not sufficient to meet the needs of the 21st century. Grabinger (1996) writes that the traditional teacher-centered model of teaching is based on five erroneous assumptions concerning learning:

(1) learning is transferable from one situation to another,

(2) learners are passive receivers of knowledge,

(3) behavioral-based learning strengthens the bonds between stimuli and response,

(4) learners are empty slates ready to be overwritten with knowledge, and

(5) learners best acquire knowledge and skills independent of realistic context for use.

This system of education produces students who "treat information as facts to be memorized and recited rather than as tools to solve problems relevant to their own needs" (Grabinger, 1996, p. 2). Perkins (1991) believes this process creates in inert knowledge; information memorized devoid of context that may be relevant to new situations, but not transferable (Grabinger, 1996; Perkins, 1991; Bransford & Vye, 1989). Decontextualized learning results in learners unable to recall and transfer knowledge and skills to new and novel situations.

<u>New Learning Environment</u>

In contrast to the traditional model of education, the consensus among educators and scholars converges on the notion that today's complex world requires the ability to use tools and knowledge in a variety of domains and situations. These critical-thinking skills allow people to

fully participate in our modern, information-age society by giving them the ability "to solve technical, social, economic, political, and scientific problems" (Grabinger, 1995, p. 1).

The question then becomes how to encourage critical-thinking skills development in students rather than the formation of inert knowledge. According to Reiser and Salisbury (1995) the key to developing critical-thinking ability involves using instructional strategies that (1) increase time on task, (2) increase the amount and relevance of feedback to each student, (3) use a performance-based system to assess student achievement, rather than a system where all students spend the same amount of time studying instructional material, and (4) incorporate self-paced instruction geared to student capabilities rather than class average. These student-centered strategies encourage engaged student learning which provides students the independent, flexible, innovative, and complex problem-solving skills that employers believe workers of the future require (Benton Foundation, 1995). A student-centered approach to learning, therefore, promotes achievement of the basic goals of education--retention, understanding, and active use of the knowledge and skills (Perkins, 1991). As Perkins (1991) writes:

> Surely we want what is taught retained, else why teach it? Unless knowledge is understood, to what purposes can it be put? Finally, having and understanding knowledge and skills come to naught unless the learner actually makes active use of them later in life. (p. 18)

This student-centered approach is a constructivist view of cognition (Bednar, Cunningham, Duffy, & Perry, 1995) which considers learning as a process where the learner builds an internal and personal representation of knowledge based on experience. This learning is an active process embedded within social and collaborative interactions among students. Rather than focusing on the teacher as disseminator of information (teacher-centered model of education),

constructivism focuses on the student sharing perspectives with the teacher and other students and then modifying internal representations of knowledge in response to this sharing experience (student-centered model of education). Therefore, learning is a process of constructing, interpreting, and modifying representations of reality based on experience. Wilson (1996) concisely defines this constructivist learning environment as "a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities" (p. 5). Figure 1 compares the traditional and constructivist models of education.

Figure 1
Comparison of Traditional and Constructivist Models of Education

Traditional Model	Constructivist Model
Teacher centered and directed	Student centered; explorer role; goal oriented
Didactic teaching	Interactive instructional strategies
Teacher dispenses knowledge	Teacher facilitates and coaches
Individual work	Collaborative, active, social work
Short blocks of single subject instruction	Challenging, authentic, multidisciplinary blocks of instruction
Assessment of quantifiable factual knowledge and skills	Performance-based assessment

Technology's Role in School Reform

As policy-makers, educators, parents, and business leaders wrestle with why and how to reform education to increase achievement and promote problem-solving abilities, another

confounding factor enters the picture--the information society. Many people have written about the impending impact of the information age on society. The Benton Foundation (1995), for example, reports that " advanced telecommunications technologies are increasingly shaping how we work, play, and relate to one another" (p.1). The Department of Labor (as cited by the Benton Foundation, 1995) provides the following sobering statistics to back the Benton Foundation's statement: almost 50 percent of all workers use computers on the job (double the rate of just 10 years ago) and those workers using computers earn 43 percent more than non-computer using workers. And the number of jobs requiring information technologies skills is expected to increase to 60 percent by the year 2000 (Hawkins, 1996). Also approximately 37 percent of households have computers, and while not all are connected to computer networks, the number that is growing exponentially (Benton Foundation, 1995). These statistics indicate the significant impact technology levies on society.

Viewed strictly from a school-to-work perspective, technology adoption and use appears necessary to arm students with the basic computer skills required to survive in the 21st century. Dyrli and Kinnaman (1995) support this contention:

> Integrating computer-based telecommunications activities into your curriculum gives your students the experience of using the very same online tools that are used by people in almost every profession, and prepares them for the emerging future where such information and communications skills will be of paramount importance. (p. 87)

However as stated earlier, future society demands critical-thinking skills as well. Frank Withrow, director of learning technologies for the Council of Chief State School Officers, best illustrates the impact of the information age. He writes that "In 1850, it took about 50 years to

double the world's knowledge base, today it takes only a little more than a year. The way we store, retrieve, and use information is vastly different in the Information Age. The U.S. work force does not need 'knowers,' it needs 'learners'" (as cited by the Benton Foundation, 1995, p. 4).

Technology fosters development of the types of learners Withrow talks about by supporting a learner-centered environment. Collins (1991) identifies the following trends in schools that have adopted computers:

(1) a shift from a whole-class, teacher-centered learning environment to small-group instruction;

(2) a shift in the teachers' role from lecturer to coach and facilitator;

(3) a shift from working primarily with better students to working with weaker students;

(4) a shift to more engaged and motivated students;

(5) a shift from assessment based on quantity of knowledge to product-based assessment that measures retention, understanding, and active use of the knowledge;

(6) a shift to a cooperative social learning structure from a competitive structure; and

(7) a shift toward individualized education in which, rather than all students learn (memorize) the same things, students learn different things.

These trends reflect a constructivist learning environment that is experiential and activity-based (Dewey, 1938) "in which a student can 'master new knowledge and skills, critically examine assumptions and beliefs, and engage in an invigorating, collaborative quest for wisdom and personal, holistic development'" (Jonassen, et al., 1995, p. 7). This environment produces the critical thinkers able to frame and solve ill-defined problems in an information-rich world. Thus technology not only possesses the ability to provide valuable life skills to American students, but

also the potential to transform education. As the 1996 National Education Summit attendees proclaim "We are convinced that technology...can be utilized as a helpful tool to assist student learning, provide access to valuable information and insure a competitive edge for our workforce" (1996 National Education Summit Policy Statement, p. 2). Integrating technology into the classroom "substantially improve(s) access to the best instructional methods and materials for all students" and "provide(s) students with the hands-on experience to develop the knowledge and skills they will need to compete successfully in the workplace" (1996 National Education Summit Policy Statement, p. 3).

What Correlation Exists Between Technology Use and Student Achievement?

Technology and Student Achievement

Since the first computer entered public education, literally thousands of studies have investigated its educational effects. Although criticism and controversy exists, much of this literature demonstrates technology's positive effects on achievement. Space limitations prevent an exhaustive presentation of this research, therefore I present studies (meta-analyses and longitudinal studies) representative of the major research approaches, as well as some of the criticisms of these approaches.

Meta-analyses

Meta-analysis is a method of assessing the statistical results from many different studies into a single finding by using effect size (Krathwohl, 1993). Effect size is a score in standard deviation units; an effect size of .3 means that the average person in the treatment group performs about .3 standard deviations better than the average person in the control group. Kulik and Kulik (1991) performed a meta-analysis of 254 studies examining the effects of computer-based instruction for

kindergarten students through the college level and found an effect size of 0.3. These results have been corroborated by many other researchers as well. For example, Khalili and Shashaani (1994) completed a meta-analysis of studies completed between 1988 and 1992. They report that "the overall use of the computer as an instructional tool continued to be effective for learning and achievement across different grade levels. The average effect size in this meta-analysis was .38" (p. 56). These results seem to indicate the potency of computer-based education.

Interactive Educational Systems Design (1996), an independent consulting firm, contracted with the Software Publishers Association to perform a meta-analysis of the effectiveness of technology in schools. One hundred and seventy-six studies conducted from 1990 to 1995 were analyzed. The report concludes that "technology is making a significant positive impact in education" (p. 2). Important findings include:

(1) positive effects exist throughout education (preschool through higher education), for both regular and special needs students in all major subject areas;

(2) technology positively affects student attitudes toward learning and self-concept; and

(3) technology introduction enhances cooperation and collaboration, increasing teacher-student and student-student interactions.

Criticism of Technology's Effects

Results of the magnitude reported above lead proponents to extol the benefits and potential of technology. However, other researchers remain skeptical. McKenzie (as cited by Wellburn, 1996, p. 3) states that "the most substantial research into student learning with technologies has examined performance on lower order tasks and basic skill...Too little work has been done measuring gains in higher order skills." Many, if not most, of the studies comprising the

meta-analyses above report results from drill and practice applications. Additionally, these meta-analyses attribute effect to medium (computer) alone, igniting considerable debate among researchers. Clark (1983; 1994), for example, believes that instructional methods embedded in the medium influences learning. He states that "...media do not influence learning under any conditions," but serve as delivery vehicles for instruction (1983, p. 445). Kozma (1991), on the other hand, believes that the medium and methods combine to interact with and influence how students learn and process information. These criticisms lead Means, et al. (1993) to write "The accumulation of comparative studies, biased in their choice of control groups or outcome measures, does little to help us understand what features of the treatment are critical for producing the desired effects" (p. 76). These limitations have given rise to longitudinal studies and other contextual approaches (Means, et al., 1993) which demonstrate technology's potential for supporting a learner-centered approach to education.

Longitudinal Studies

Apple Computer, Inc. (1995) began its ACOT (Apple Classrooms of Tomorrow) project in 1985 to explore what happens to students and teachers when they have access to computers whenever they need it. They supplied computers and trained the teachers at two sites initially, adding more sites and teachers over the years. Dwyer (1994, p. 4) reports that "After nearly eight years of studying the effects on classrooms, ACOT researchers have observed profound changes in the nature of instruction, learning, assessment, and the school culture itself." Detailed reporting of the findings are beyond the scope of this paper, however Apple's (1995) comprehensive ACOT research demonstrates that technology significantly increases the potential

for learning, "especially when it is used to support collaboration, information access, and the expression and representation of students' thoughts and ideas" (p. 24).

The CHILD (Computers Helping Instruction and Learning Development) study, which started in 1987, investigated the impact of computers on over 1,400 students and their teachers from nine Florida elementary schools (Kromhout & Butzin, 1993). Each participating teacher received technical training with the computers, as well as training emphasizing a team approach with other participating teachers. Three to six computers were placed in each participating classroom. Curriculum and computers were totally integrated. Results of the study showed positive and statistically significant standardized test scores for all participating grades and schools; the largest effects appeared for students involved in the program for greater than one year. At the conclusion of the study in 1992, none of the schools expressed dissatisfaction with the project; in fact five schools planned to expand their level of participation, and nine new schools were about to join CHILD (Kromhout & Butzin, 1993). These longitudinal studies, as well as other contextual-based research (see Means, et al, 1993, for a short synopsis), support the conclusion that "...when used as part of an instructional approach involving students in complex, authentic tasks, technology can support the kind of transformation of student learning that is at the heart of education reform" (Means, et al., 1993, p. 78).

What is the Status of Educational Computing?

Since 1975, when the first microcomputer was developed, computers have moved into U.S. schools at an unprecedented rate (Sutton, 1991). Becker (1983) reports that by 1981 the majority of secondary schools owned at least one computer and, by 1985, over 90% of public schools owned at least one microcomputer (Office of Technology Assessment, 1987). The Office of

Technology Assessment (1995) estimates that by the spring of 1995, 5.8 million computers will call K-12 schools home; about one computer for every nine students. Despite this large investment in computers by schools and the vast body of literature demonstrating how to benefit learners through technology-rich educational environments, why does Marcinkiewicz (1993) find that computers are underutilized? Or as Peck and Dorricott (1994) phrase it, "Why do schools rumble along virtually unchanged by the presence of computers" (p. 11)?

This question is particularly troubling for two reasons: (1) based on the notion that technology integration can lead to higher-level learning skills and life-skills acquisition, tremendous support exists for integrating computers into education, and (2) the existence of many successful integration efforts demonstrating the potential of technology adoption. For example, the 1996 National Education Summit attendees believe that "Interactive learning enables parents and educators to find new ways to help students improve academically, while helping students to learn to use the tools that are being used not only in today's high-technology workplaces, but increasingly in any workplace" (National Education Policy Statement, p. 2). Examples of successful use include:

(1) Patricia Weeg, a teacher at Delmar Elementary School, who uses KIDLINK to link students from all over the world together with her students in a global dialogue. She (as cited by the Benton Foundation, 1995) states "My curriculum has never been so alive, so up to date, so exciting for me....The world is our classroom! In the global classroom, the curriculum is a 'living' curriculum with real people--not textbooks--feeding our desire to learn and explore" (p. 2).

(2) Peakview Elementary School which infused more than 80 networked microcomputers, related technology, and software while restructuring. Wilson, Teslow, Cyr, and Hamilton (1994) found that:

(1) technology positively affected student attitudes and learning,

(2) teachers adapted instruction to accommodate students' interests and increased the effective use of cooperative learning activities,

(3) students used the technology for instructional support in many subject areas, as well as extensively using the technology for writing and research activities, and

(4) technology positively impacted how teachers worked instructionally and professionally, resulting in greater satisfaction, effectiveness, and productivity.

<u>Barriers to Technology Integration and Use</u>

Despite the huge investment in computers by the public education system, the growing body of research indicating that computers can serve as tools to facilitate a constructivist approach to teaching and learning, the examples of successful technology integration efforts (see also Hawkins, 1996), and the high levels of support, technology's role in educational reform continues to rank as one of the top issues of debate. While pockets of success spring up throughout the public education system (e.g. Patricia Weeg and Peakview Elementary School), technology still is used predominantly for basic skills acquisition in elementary schools and for word processing and learning basic computer skills in secondary education (Hawkins, 1996). Facts such as these lead researchers to ask why "businesses have been building an electronic highway, [while]

education has been creating an electronic dirt road" (Peck & Dorricott, 1994, p. 11)? This question leads to an examination of the barriers blocking successful integration and use.

Recognition that barriers do exist thwarting the successful integration of technology into education represents a step in the right direction. For example, the leaders meeting at the national education summit also stated that:

> Governors and business leaders need to support educators in overcoming the barriers that impede the effective use of technology. Such barriers may include the complexities of planning for the acquisition and integration of technology into classrooms and schools; the high costs of acquiring, developing, and maintaining it; the lack of school technology policies; resistance to change from individuals both within and outside the education system; and most important, the need for staff development and curriculum change. (National Education Policy Statement, p. 2)

Although no longer operating, the Office of Technology Assessment (OTA) also recognizes the challenges facing effective technology integration into public education. In a 1995 report entitled, *Teachers & Technology: Making the Connection*, OTA identifies and discusses similar barriers to technology use (teacher time, access, costs, and training and support). The remainder of this paper discusses these barriers and then offers strategies to overcome them.

<u>Resistance to Change</u>

Although the education summit attendees rank staff development as the most important barrier, I believe peoples' innate dislike for change (especially mandated change from above) is the most significant barrier to technology integration. Cohen (as cited by Hodas, 1996) points out that schools and the nature of teaching have remained relatively unchanged for hundreds of

years. Given this stable nature of schooling, "any practice that threatens to disrupt this existing structure will meet tremendous resistance at both adoption and implementation stages" (Hodas, 1996, p. 2). In reality teachers are being asked to make two radical changes to their existing pedagogy--not only learn how to use technology, but also to fundamentally change how they teach. Means and Olson (1995) write that "The move to project-based work, without relying on lecture methods or following a textbook, is a more fundamental and difficult shift than the introduction of technology" (p. 12).

In addition to a basic resistance to change, Marcinkiewicz (1994) believes "people avoid using computers for the following reasons: fear of loss of status, ignorance, fear of unfamiliar procedures, and fear of loss of hard-earned skills" (p. 186). The literature corroborates this assessment. For example, Budin (1991) writes "Since the introduction of microcomputers into schools...an undercurrent of teacher anxiety has pervaded discussions of their use" (p. 15). He contends that computers evoke hope and fear concerning how they will affect students' learning and teachers' work. Some teachers fear they might be replaced by computers while others fear losing control of the classroom. Additionally, since many teachers are likely to know less about computers than their students, the fear of embarrassment acts as a major deterrent to acquiring the skills required to effectively use computer technology in the classroom (Hodas, 1996).

Finally, the manner in which change occurs also impacts success. "Research shows that change in schools requires leadership, staff development, modification of the organizational structure, and the involvement of people from all aspects of the educational system" (Russell, Sorge, and Brickner, 1994, p. 66). Unfortunately, when it comes to technology integration into the education system, "computers came into schools not as means but as an end. The

commandment seemed to be thou shalt have computers, not thou shalt use computers in appropriate effective ways" (Young, 1991, p. 144). Citing previous research concerning top-down educational innovations, Means, et al. (1993) write "When required to adopt an innovation, districts and schools have a tendency to take on its superficial features without really incorporating its substance" (p. 92). This supports Smith and O'Day's (as cited by Means & Olson, 1993) contention that teachers have closed their classroom doors and gone on teaching just as they were taught.

Professional Development: Training, Time, and Support

Not only were computers "mandated from above," which most people dislike, but appropriate training to provide teachers with experience to develop their skills and enhance their self confidence appears to have been an afterthought. Learning new skills in any profession requires time, however teachers have little time left after spending the great majority of their day instructing students in class, meeting with parents, and attending staff and committee meetings (OTA, 1995). According to Sheingold and Hadley (1990), even accomplished, highly motivated technology-using teachers rank lack of time as among the most problematic barriers to integrating computers into schools. Teachers require time to experiment with technology, share their experiences with colleagues, and attend technology-related in-service training programs.

In addition to time constraints, limited spending by school districts significantly reduces training and support (OTA, 1995). Typically only four to fifteen percent of a school district's technology budget is spent on training. Also only six percent of elementary schools and three percent of secondary schools have a full-time on-site technology coordinator. However, the reality is "teachers cannot use technology unless they understand how, when, and where to use it.

Only education will close the loop" (Young, 1991, p. 144). The lack of training, time, and support represents a very significant barrier.

Access

Despite the impressive number of computers schools possess (approximately 5.8 million) a large number of teachers report little or no use of classroom computers for instruction (OTA, 1995). However, numbers alone do not guarantee adequate access. Access is more than simply the availability of technology in a school; access involves locating the proper amount and right types of technology where teachers and students can use them effectively. Effective access requires connectivity, ubiquity, and interconnectivity (Jones, Valdez, Nowakowski, & Rasmussen, 1994). Connectivity provides the capability to access rich resources within and beyond the school. Ubiquity means locating the computers and peripherals where everyone within the school has access to them when they need them. Interconnectivity allows teachers and students to communicate and collaborate.

With 5.8 million computers and a 9-to-1 student-to-computer ratio why is access a problem? OTA (1995) provides the answer:

(1) In sheer number of instructional computers, the United States leads the world. However, about half of these computers are 8-bit machines incapable of supporting CD-ROM-sized data bases, run complex software, or network integrated systems. This limits use of some of the most exciting computer applications.

(2) Computers are used predominantly for lower-order thinking skills.

(3) Schools typically locate their technology in inaccessible spots. About one-half of all computers used for instruction in 1992 were located in centralized computer labs, with

about 35 percent located in classrooms. The rest reside in media centers, teacher's offices, and the main office.

(4) Other important technologies are even more inaccessible to the classroom teacher. For example, telephones, fax machines, and modems, are usually located in an office and are accessible only to administrators or during restricted hours. Only 38 percent of schools have a modem and only 9 percent have access to the Internet. Less than one teacher in eight has a classroom telephone.

Either the technology is nonexistent or it is outdated, inaccessibly placed, and used ineffectively. Based on the requirements of connectivity, ubiquity, and interconnectivity, clearly access presents a problem to effective integration and use of technology.

A final issue impacting access involves the differences in computer resources among schools. Enormous variability exists in student-computer ratios from school-to-school both within and across school districts (OTA, 1995). For example, one elementary school might have a ratio of one computer to thirty-five students, while another elementary school averages one computer per seven students. Equitable distribution presents equity issues for learning; the Benton Foundation (1995) believes unequal access represents "perhaps the biggest concern...to connecting the nation's classrooms..." (p. 8).

Cost

Typically schools focus on the obvious initial costs associated with buying hardware, without giving much consideration to the costs associated with software acquisition, maintenance and repair, training and technical staffing, replacement and system upgrades, and telecommunications connections (Means & Olson, 1995). In the aggregate schools spend approximately $2.7 billion

dollars per year on technology, however Rothstein (as cited by the Benton Foundation, 1995) estimates the installation cost of providing up-to-date computers linked to a communications network could cost between $11.8 and $30 billion initially ($267 to $625 per student), with annual operating costs running between $1.9 and $4.9 billion ($42 to $112 per student). These costs just represent hardware acquisition. In addition, due to differences in school location and drastic differences in existing resources and infrastructure (inadequate wiring and electrical power, air conditioning, ventilation, lighting, and security systems) the GAO (as cited by the Benton Foundation, 1995) estimates that it will require about $112 billion to repair and upgrade all school facilities to accommodate full use of technology. Despite the increasing affordability of technology, costs of this magnitude represent a significant barrier to technology integration.

Implementation

As stated earlier top-down mandated change, more often than not, results not only in resentment, but also a superficial level of compliance. The flip side to top-down change is bottom-up reform. While tremendous individual energy and effort characterize the bottom-up approach and students benefit in this environment, typically these efforts die off when their champions leave or the children move on to other grades and teachers not incorporating the same teaching principles or technology use. The same problem occurs when individual schools initiate and sustain change. For example, when the children leave Peakview Elementary School for middle school, will they encounter the same or similar instructional practices and uses of technology? Probably not. While the literature contains many examples of successful individual (see also Ferris & Roberts, 1994; Apple, 1995) and school-level (see also Means & Olson, 1995;

Wilson, Teslow, Cyr, & Hamilton, 1994; Apple, 1995) efforts to technology integration, perhaps the appropriate level from which to attempt reform resides at the school district level. This level combines the staying power of systemic reform supported by a larger organization with the opportunity to give local stakeholders power to provide local input and control. It also gives the school district the opportunity to sequence the integration of technology throughout the elementary and secondary levels to ensure students do not move from a technology-intensive school to a more traditional school or vice versa.

School District's Goals

"In and of themselves, technologies are essentially neutral with respect to instructional principles. A given technology can be used to support almost any instructional philosophy" (Means, et al., 1993, p. 83). As discussed earlier computers have been used predominantly for drill and practice emphasis of lower-order thinking skills. However, placed in an educational setting that values and embraces a learner-centered approach to education, that same computer becomes a tool to support complex problem-solving, critical-thinking, and multidisciplinary work. In such an environment, technology is not an end in itself, but a means to an end; a means to improved quality of teaching and learning.

The first order of business for any school district to consider when contemplating large scale expenditures for technology, involves establishing the curricular and pedagogical goals technology integration is to support. As Sheingold (1991) writes:

> It is now well understood that the challenge of integrating technology into schools and classrooms is much more human than it is technological. What's more, it is not fundamentally about helping people operate machines. Rather, it is about helping people, primarily teachers,

integrate these technologies into their teaching as tools of a profession that is being redefined through the incorporation process. (as cited by Means, et al., 1993,p. 84)

If the school district wishes merely to reinforce the status quo emphasizing basic competency skills development, then the money would be better spent purchasing textbooks, worksheets, and other basic teaching materials. On the other hand, if these goals involve a constructivist philosophy emphasizing problem solving and intellectual effort, then technology integration is appropriate.

Academy District 20's mission statement reads "To provide a rich, academically rigorous curriculum as the foundation upon which students are encouraged to build for success." Further the philosophy statement reads in part that "...The curriculum should provide students with the cognitive skills necessary for further education, training, or successful integration into the work force." To support this mission and philosophy, the district has adopted the idea of establishing world class schools characterized by the following elements: (1) an integrated curriculum which provides both content and process (e.g. problem solving and critical thinking skills), (2) new teaching methodologies, (3) maximizing individual student potential in areas of interest, (4) positive student attitudes and motivation, and (5) a quality school-to-work program. District 20's mission and processes for achievement reflect a constructivist approach to education and appear ideal for technology adoption and integration.

Resistance to Change

As implied by Sheingold (above) and previously discussed, technology integration requires both a reorientation concerning teaching and learning (the most difficult change) and acceptance of technology as a means to support this change in teaching philosophy. Thus the first barrier to

technology integration--peoples' inherent resistance to change--appears. The attending question is how to assist schools and teachers to embrace pedagogical and technological change. Since school reform lives and dies with teachers, granting teachers a transformative role by "giving teachers a greater voice in curriculum decisions and incorporating technology" (Budin, 1991, p. 22) is imperative for success. Given the opportunity to participate in the decision-making process, District 20 teachers are more likely to embrace the reforms and changes resulting from a collaborative process in which they play a major role.

Typically District 20 uses committees and task forces, composed of various stakeholders, to study a variety of issues. Technology is no different. However, given the magnitude of change resulting from this technology committee, teachers should comprise the majority of members. Since these teachers will become the emissaries of change, they should be carefully selected to participate in the planning process. They should represent a broad cross section of views and attitudes toward pedagogy and technology, as well as grade-levels and subject areas.

Professional Development

A corollary to granting teachers more voice is the realization that integrating technology and pedagogical changes takes training, time and technical support. Training teachers how and when to use technology in their classrooms is crucial to effective integration of computers. District and school administrators must provide appropriate in-service, staff development, and intervention strategies to ensure teachers understand how to most effectively and efficiently incorporate computers into their teaching practices. Young (1991) argues that teacher education programs must restructure to incorporate technology across the undergraduate and graduate curriculum, since teachers learn by modeling just like their students. Budin (1991) correctly asserts:

Teachers must not be merely implementers of programs but decision makers, and that integrating technology into schools means not only training teachers to run software that supplements their curriculum, but making them expert enough about the technology to make meaningful decisions about how computers can be used to their potential. (p. 16)

To attain the level of competence Budin describes requires a significant time commitment because teachers proceed at different speeds. For example, Apple (1995) found that teachers typically progress through various technology adoption phases (entry, adoption, adaptation, appropriation, and finally invention) as they learn how to operate and use the technology to support a learner-centered approach to teaching and learning. Similarly, teachers fall along a bell-shaped curve (innovator, early adopters, early majority, late majority, and laggards) according to their willingness to embrace an innovation (Moore as cited in OTA, 1995). These models suggest that a great deal of variability exists among teachers concerning how quickly they will accept new technologies. Specifically, Moore's model suggests the necessity to develop intervention strategies aimed toward the early and late majority adopters. Also targeted intervention strategies possess the potential to expedite the learning process and move teachers more quickly along Apple's adoption continuum. However, "schools and districts...need to understand that this is a long-term process, and teachers need to be given the supports and the time to become comfortable with technology and to learn to use it effectively" (Means & Olson, 1993, p. 19).

Finally, technical support is paramount to ensuring successful technology integration and use. Means and Olson (1993) identify the need for on-site technical assistance to provide:

(1) help in planning for technology uses,

(2) training how to use new hardware and software,

(3) demonstrations and advice on how best to incorporate technology into instruction,

(4) on-demand help with hardware failures or software problems, and

(5) low-level system maintenance.

Help of this nature provides teachers with assistance when they need it, otherwise if problems arise and teacher's have to wait extended periods of time for assistance, they may abandon their efforts to incorporate technology (Means & Olson, 1993).

Research supports the critical need for professional development. Becker (1994) identified 5% of computer-using teachers as exemplary. He then looked at how the exemplary computer-using teachers differ from other teachers in three areas: (a) the school and classroom environment in which they work (including the students they teach), (b) the teachers' backgrounds and experiences, and (c) how the teachers carried out their teaching practices and their perceptions concerning teaching and computer use. He found:

(1) consistent association between investment in support and training of personnel and the presence of exemplary teaching practice using computers. "One of our most consistent findings was that exemplary teachers worked in school districts that had invested heavily in staff development and on-site staff support for computer-using teachers" (Becker, 1994, p. 305);

(2) that exemplary computer-using teachers spent twice as much time working on computers at school than the other computer-using teachers, and exemplary teachers had more formal training in using and teaching with computers;

(3) that exemplary computer-users changed their coverage of curriculum topics much more

often due to using the computers and that they were more flexible in integrating small-group work and giving the students a choice in selecting software.

Marcinkiewicz (1994) studied how a set of internal variables (perceived self confidence with computers, perceived relevance of computers to teaching, teacher locus of control, innovativeness, and demographic data concerning the teachers' previous computer experience) affect the levels of computer use of practicing and preservice elementary school teachers. He found that "Self-competence and innovativeness were identified as most closely related to the teachers' levels of computer use" (p. 192). Marcinkiewicz (1994) concludes that staff development that accounts for these internal variables improves teaching effectiveness with computers.

Given the critical nature of providing appropriate professional development opportunities, what are some strategies District 20 can use to provide teachers the training they need?

(1) Give teachers a computer for personal use. Means and Olson (1993) report that many of their case study sites provided loaner computers for personal use with great success. Peakview Elementary School used this strategy during its implementation phase. Teachers took computers home for six weeks during the summer which gave them the time to become familiar and comfortable with the technology before the school year began (Wilson, Teslow, Cyr, & Hamilton, 1994).

(2) Provide monetary and recognition incentives to teachers for designing effective instructional uses of technology. Means and Olson (1993) cite examples such as mini-grants, proposal competitions, or encouraging teachers to work as consultants during school year breaks to develop instructional uses of software.

(3) Increase the number of in-service days, either during the school year or during summer, targeting specialized training in instructional practices and technology use. "Regular in-service lessons provide [teachers] with the opportunity to interact with other people, to pursue new skills, and receive help on their problems or areas of concern" (Wilson, Teslow, Cyr, & Hamilton, 1994, p. 212).

(4) Restructure the school day to provide teachers with more time to plan and develop curriculum and to consult with other teachers. Apple (1995) found that giving teachers time for self reflection and to collaborate with peers significantly influences successful teaching practice and technology adoption efforts. This sort of interaction builds on itself and promotes technology integration which supports Becker's (1994) finding that exemplary teachers were found in schools that had nearly twice as many computer-using teachers.

(5) Provide a technology coordinator with an understanding of instructional issues, in addition to technical expertise, at each school. The optimal solution calls for this to be a full-time, stand-alone staff position. Wilson, Teslow, Cyr, and Hamilton (1994) found a strong, knowledgeable computer coordinator is critical because this person "seems to give other teachers the courage to charge ahead in the use of technology" (p. 211). A willing and able teacher can fill the role, however, if problems arise this teacher may not be available right away to help solve the problem.

"Unless the classroom teacher can effectively use educational technology, its potential for facilitating and enhancing the teaching/learning process will never be [fully] realized" (Hunt and Bohlin, 1993, 487).

Access

Equal Access

"Technology use in schools should be designed and implemented so that all students have access to rich and challenging learning opportunities and instruction that is interactive and generative" (Jones, Valdez, Nowakowski, & Rasmussen, 1994, p. 18). This statement addresses the twin issues of equal access and adequate access. The Benton Foundation (1995) chronicles the very real concern that the information superhighway may widen the gap between rich and poor Americans. While government intervention into the education system can mitigate this to some extent (e.g. Chapter I has narrowed the disparity in access to computers between poor and rich schools) significant differences, based on socioeconomic status, show up in student access to computers outside of school (Benton Foundation , 1995). The consequences are serious.

> Many students become familiar with information technologies in a general sense. But those who cannot claim computers as their own tool for exploring the world never grasp the power of technology. Such students become passive consumers of electronic information....They are controlled by technology as adults--just as drill-and-practice controlled them as students. (Benton Foundation, 1995, p. 7)

Access disparity certainly warrants the attention and concern it receives when viewed from the state or federal policy levels, however given the solid middle to upper-middle class socioeconomic status and relative homogeneity that exists in District 20, unequal access is not as problematic for its students. Nevertheless, it is naive to think that every household in the school district has an on-ramp to the information superhighway. Inequality does exist and given the competing demands for each educational dollar, it is also naive to think that district taxpayers

would support funding to purchase computers for every deserving child to take home in addition to supporting the funding levels necessary to integrate a technology-enriched curriculum. Strategies used by successful technology-adopting schools to address this issue include instituting a minimum level of computer exposure per day or week for each child, providing before, during, and after-hours programs, and providing loaner computers on a limited basis (Means & Olson, 1995). As part of its overall plan, District 20 should consider adopting all of these suggestions with the caveat that these programs not perpetuate drill-and-practice computer use, but to experiment and explore the computer's capabilities to provide access to wider bodies of information.

Adequate Access

One computer per student and teacher for every school would represent the ideal situation, however given the practical realities of school funding, the objective becomes to place "a critical mass of computers and other equipment...throughout the school so that teachers and students can use them when they need them" (Jones, Valdez, Nowakowski, & Rasmussen, 1994, p. 18). Like every barrier and solution discussed so far, adequate access is a function of funding, but usually receives the greatest visibility because it represents the hardware buy decision (how many computers, what types, etc.). Student-to-computer ratio therefore, determines which strategy, from among several possibilities, best offers adequate access. Figure 2 lists computer distribution strategies typically used by schools, as well as the major advantages and disadvantages for each. Since school reform and technology adoption do not occur overnight, and as funding and levels of compliance vary over the course of change, schools tend to move among and combine strategies. This expectation is no different for District 20. However,

research demonstrates that the more resource rich the teaching and learning environment (more computers and software per student and the smaller the classrooms) the more effective school reform of this magnitude (Becker, 1994; Wilson, Teslow, Cyr, & Hamilton, 1994). For a more detailed description of computer allocation strategies, see *Restructuring Schools with Technology: Challenges and Strategies*, written by Means and Olson, 1995).

Figure 2

Technology Allocation Strategies

Scheduling

One of the hallmarks of learner-centered, project-based learning is the realization that this type of learning does not fit into neat, segmented blocks of time, but that students must devote considerably longer periods of time to the learning process. Since technology is a tool to support and enable this type of learning environment, scheduling technology-based activities represents a subset of the access issue, particularly since it takes time to navigate through the software programs to empower student critical-thinking (Means & Olson, 1995). At the elementary school level the flexibility exists to foster this type of environment, however in the typical middle school and high school, instruction and time are more compartmentalized. School District 20 should consider restructuring the school day at these levels to provide more time for sustained student inquiry and active learning. According to Means and Olson (1995), middle schools and high schools that changed to 85- and 90-minute periods, found the increased time

and flexibility critical for technology-supported work; whereas traditional 50-minute block periods hindered efforts to meaningfully integrate technology-supported student learning in schools that chose not to alter the teaching schedule.

Costs

Cost estimates vary a tremendously, but the fact remains that technology represents a significant investment by any school district. Means and Olson (1995) provide a useful framework for estimating the broad array of costs associated with technology adoption and integration. They estimate the total annual cost per student to be $463. This cost is based on the following assumptions:

(1) personnel support includes: one full-time technology coordinator and one half-time technician per school; formal staff development (2 days/year for 15 teachers), teacher planning time (400 hours per year); and teacher networking time (2 hours per week). Total cost: $269 per pupil per year.

(2) equipment and material includes: computers (4:1 student-to-computer ratio; 5 year equipment life; purchase of new computers for 5% of students per year); peripherals and software; telecommunications connections; maintenance (3% of capital expense of equipment over 5-year period); and infrastructure (wiring, furniture, etc., amortized over 10 years). Total cost: $194 per pupil per year.

Based on an enrollment of 15,000 students the estimated annual cost of technology adoption in District 20 is $6.9 million. Given the relative newness of District 20 schools, which will save on infrastructure costs, and the ambitious student-to-computer ratio compared to District 20's ideal of 5:1, the cost estimates may be slightly high. The personnel costs reflect Means and Olson's

emphasis on human support and are in line with recommendations of policy analysts (OTA recommends spending at least 30%, but preferably more, of the technology budget on professional development), therefore I would recommend against pinching pennies in this area. Assuming a budget of approximately $4,200 per student in District 20, this outlay requires only 10% of the budget. Also outside sources of funding (grants, business-education partnerships, etc.) are not factored into this analysis.

Leadership

School reform will not happen on its own. Inspiring, transformational leadership is necessary to initiate and sustain the level of reform discussed in this paper. This level of reform asks teachers to undergo two major changes--adopt a new teaching philosophy (constructivism) and incorporate technology in the process. Strong district-level leadership, supported by equally strong school-level leadership, is necessary to create the shared vision and commitment conducive to successful implementation. As discussed earlier a collaborative district culture providing all stakeholders, but especially the teachers, a voice in shaping the vision and goals of school reform will increase the confidence and the value teachers place on achieving that vision (Bass, 1985, p. 39).

Summary and Conclusion

Is technology a panacea that will lead to educational utopia? Miller and Olson (1994, p.121) write "The history of innovation in education teaches us to be cautious about predictions associated with new technologies. However, there is something about computers that seems to negate this caution." Computer technology possesses the potential to help transform education, to provide the critical-thinking and life skills necessary for the future. However, in order for

computers to be integrated into the curriculum, computers must become critical to teaching (Marcinkiewicz, 1994). "Curriculum integration is central if technology is to become a truly effective educational resource, yet true integration is a difficult, time-consuming, and resource-intensive endeavor" (OTA, 1995, p. 2).

Educators are the key link in how, not if, technological change happens. How rapidly and effectively this technological change occurs, depends to a large degree on the willingness of educators, especially teachers, to change pedagogical philosophies. Overcoming teachers' resistance to change is just one barrier to technology integration; professional development, access, and costs represent the other significant barriers. The key to successful adoption and integration resides in the collaborative efforts of a school district's stakeholders to develop a long-term plan to support the vision for technology adoption. That vision is a community of active, engaged learners acquiring the intellectual skills to allow them to live, work, and play in the information-age society.

References

Apple Computer, Inc. (1995). Changing the conversation about teaching, learning, and technology: A report on 10 years of ACOT research.

Bass, B. M. (1985). Leadership: Good, better, best. Leadership and performance beyond expectations. The Free Press.

Becker, H. J. (1994). How exemplary computer-using teachers differ from other teachers: Implications for realizing the potential of computers in schools. Computing in Education, 26 (3), 291-321.

Becker, H. J. (1983). School uses of microcomputers: Reports from a national survey. No. 1. Baltimore, MD: Johns Hopkins University, Center for Social Organization of Schools.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1995). Theory into practice: How do we link? In G. J. Anglin (Ed.), Instructional technology: Past, present, and future (pp. 100-112). Englewood, CO: Libraries Unlimited, Inc.

Benton Foundation (1995, September). Communications Policy Project: The Learning Connection. [On-line]. Available: http://www.benton.org/cgi-bin/lite/Goingon/learning.html

Bransford, J. D., & Vye, N. J. (1989). A perspective on cognitive research and its implications for instruction. In L. B. Resnick & L. E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (pp. 173-205). Alexandria, VA: ASCD.

Budin, H. R.(1991). Technology and the teacher's role. Computers in the Schools, 8, 15-26.

Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42 (2), 21-29.

Clark, R. (1983). Reconsidering research on learning with media. Review of Educational Research, 53, 445-459.

Collins. A. (1991). The role of computer technology in restructuring schools. Phi Delta Kappan, 28-36.

Dewey, J. (1938). Experience and education. New York: Collier Books.

Dwyer, D. (1994). Apple classrooms of tomorrow: What we've learned. Educational Leadership, 51, 4-10.

Dyrli, O. E. and Kinnaman, D. E. (1995). Connecting classrooms: School is more than a place! Technology and Learning, 15 (8), 82-88.

Evans-Andris, M. (1995). An examination of computing styles among teachers in elementary schools. Educational Technology Research & Development, 43 (2), 15-31.

Ferris, A., & Roberts, N. (1994). Teachers as technology leaders: Five case studies. In G. Kearsley & W. Lynch (Eds.), Educational technology: Leadership perspectives (pp. 53-75). Englewood Cliffs, NJ: Educational Technology Publications.

Grabinger, R. S. (1996). Rich environments for active learning. In D. H. Jonassen (Ed.), Handbook on instructional technology research. New York: Scholastic Press.

Hawkins, J. (1996). Technology in Education: Transitions. [On-line]. Available: http://www.summit96.ibm.com/brief/papers/transit.html#reading

Hodas, S. (1996). Technology refusal and the organizational culture of schools. [On-line]. Available: http://homepage.seas.upenn.edu/~cpage/techref.html

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer-mediated communication in distance learning. The American Journal of Distance Education, 9 (2), 7-26.

Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. (1994). Designing learning and technology for educational reform. North Central Regional Educational Laboratory.

Khalili, A. and Shashaani, L. (1994). The effectiveness of computer applications: A meta-analysis. Journal of Research on Computing in Education, 27 (1), 48-59.

Kozma, R. B. (1991). Learning with media. Review of Educational Research, 61 (2), 179-211.

Krathwohl, D. R. (1993). Methods of educational and social science research: An integrated approach. White Plains, NY: Longman.

Kromhout, O., & Butzin, M. (1993). Integrating computers into the elementary school curriculum. Journal of Research on Computing in Education, 26 (1).

Kulik, C. C., & Kulik, J. (1991). Effectiveness of computer-based instruction: An updated analysis. Computers in Human Behavior, 7 (12), 75-94.

Marcinkiewicz, H. R. (1994). Differences in computer use of practicing versus preservice teachers. Journal of Research on Computing in Education, 27 (2), 184-197.

Marcinkiewicz, H. R. (1993). Computers and teachers: Factors influencing computer use in the classroom. Journal of Research on Computing in Education, 26 (2), 220-237.

McLaughlin, M. W. & Talbert, J. E. (1993). Introduction: New visions of teaching. In D. K. Cohen, M. W. McLaughlin, & J. E. Talbert (Eds.), Teaching for understanding: Challenges for

policy and practice (pp. 1-10). San Francisco: Jossey-Bass Inc., Publishers.

Means, B, & Olson, K. (1995). Restructuring schools with technology: Challenges and strategies. SRI International.

Means, B., & Olson, K (1994). The link between technology and authentic learning. Educational Leadership, 51, 15-18.

Means, B, Blando, J., Olson, K., Middleton, T., Morocco, C., Remz, A., & Zorfass, J. (1993). Using technology to support education reform. (Department of Education Publication No. OR 93-3231). Washington DC: U.S. Government Printing Office.

Miller, L. and Olson, J. (1994). Putting the computer in its place: A study of teaching with technology. Journal of Curriculum Studies, 26 (2), 121-144.

National Commission on Excellence in Education. (1983). A nation at risk. Washington DC: Government Printing Office.

NRENAISSANCE Committee (1994). Realizing the information future: The internet and beyond. Washington DC: National Academy Press.

Peck, K. L., & Dorricott, D. (1994). Why use technology? Educational Leadership, 51, 11-14.

Perkins, D. N. (1991). Technology meets constructivism: Do they make a marriage? Educational Technology, 31 (5), 18-23.

Pullin, D. C. (1994). Learning to work: The impact of curriculum and assessment standards on educational opportunity. Harvard Educational Review, 64 (1), 31-54.

Reiser, R. A., & Salisbury, D. F. (1995). Instructional technology and public education in the United States: The next decade. In G. J. Anglin, (Ed.), Instructional technology: Past, present, and future (pp. 254-262). Englewood, CO: Libraries Unlimited, Inc.

Russell, J. D., Sorge, D., and Brickner, D. (1994). Improving technology implementation in grades 5-12 with the ASSURE model. T.H.E. Journal, 21 (9), 66-70.

Sheingold, K., & Hadley, M. (1990). Accomplished teachers: Integrating computers into classroom practice. Center for Technology in Education. New York.

Software Publishers Association (1996). Report on the effectiveness of technology in schools, '95-'96. Washington DC.

Sutton, R. E. (1991). Equity and computers in the schools: A decade of research. Educational Technology Research and Development, 61 (4), 475-503.

U.S. Congress, Office of Technology Assessment. (1995). Teachers and technology: Making the connection. (OTA-EHR-616). Washington, DC: U.S. Government Printing Office.

U. S. Congress, Office of Technology Assessment (1987). Trends and status of computers in schools: Use in chapter 1 programs and use with limited english proficient students. (ED 291 337). Washington, DC: U.S. Government Printing Office.

Wilson, B. G. (ed.), (1996). Constructivist learning environments: Case studies in instructional design. Englewood Cliffs, NJ: Educational Technology Publications.

Wellburn, E. (1996). The status of technology in the education system: A literature review. [On-line]. Available: http://www.etc.bc.ca/lists/nuggets/EdTech_report.html

Young, E. B. (1991). Empowering teachers to use technology in their classrooms. Computers in the Schools, 8, 143-145.

1996 National Education Summit Policy Statement. [On-line]. Available: http://www.summit96.ibm.com/brief/finaledpol.html

Constructivism and Distance Education

By: John Higgs

For: Dr. Brent Wilson

Class: IT 6710 Theoretical Bases for Instructional Technology
University of Colorado at Denver

Date: December 2, 1996

Introduction

"The next decade and century will see increasingly intensive use of various modes of distance education" (Holloway & Ohler, 1995, p. 288). As information technologies explode onto the education scene, Holloway and Ohler express the predominant feelings of those involved with distance education applications to education and training. These technologies expand the potential audience for distance education because they provide a wealth of information just a keystroke away, while eliminating the necessity to assemble students at one location.

Potential is the key word when considering the future of distance education. The increasing affordability and power of information technologies, coupled with the changing American culture (mobile work force; need for frequent skill upgrades; equitable educational access for all Americans; and the desire for flexibility, options, and control over one's life) combine to ensure continued growth of distance education (Holloway & Ohler, 1995). The potential audience includes members from all segments of American society (primary and secondary education, higher education, business, and government). Miller and Clouse (1993-1994) sum up the potential information technologies offer:

> New and future advancements in technology...will offer capabilities for interactive distance learning, both in education and business. Multimedia computer system interface with CD-ROM, video discs, databases, and future advances in computer technology will greatly change distance learning programs....Classrooms will no longer be defined as stationary nor a point in time. "Just in time learning" and "on-demand education" will be available through the combination of fiber optics, compressed video, interactive television, and virtual learning environments. (p. 199)

Clearly, information technologies extend learning opportunities to a large audience without regard to location or time, but merely using technology does not guarantee successful learning. Better understanding of effective teaching and learning principles must accompany these technologies if they are to live up to their potential. Unfortunately, interactive technologies are used primarily to present teacher-dominated lectures to distance education students (Jonassen, et al., 1995). This replicates the failures and problems of conventional education classrooms, wastes potential, and is a disservice to students.

If, as many scholars believe, ineffective classroom practice produces students who only memorize and regurgitate information, what kinds of classroom practice result in successful learning? I believe the answer lies in establishing an environment that gives students the opportunity to interact with each other. A student-centered learning environment embraces the belief that knowledge construction results from an active process embedded within social and collaborative interactions among students, rather than from teacher transmission of information (Bednar, Cunningham, Duffy, & Perry, 1995; Grabinger, 1996). To truly harness the tremendous potential emerging information technologies possess, educators should use these technologies to "facilitate...'good learning experiences' in an 'extended classroom model' rather than broadcast teacher-centered lectures and demonstrations" (Burge & Roberts, as cited in Jonassen, et al., 1995, p. 7). In other words, merging active, collaborative, teaching approaches with distance education technologies should enhance the learning experience for students and result in more effective learning outcomes.

This paper examines the link between constructivism and distance education with the intent to provide a better understanding of how to facilitate constructivist approaches to distance education. Although scholars have studied and advocated constructivist approaches to conventional education for several years now, only recently has research centered on applying constructivist principles to distance education. This paper, therefore, presents a summary and synthesis of this small but growing body of knowledge.

What is Distance Education?

Traditional definitions of distance education, grounded primarily in the historic context of correspondence study, focus on the student separated by distance and time from the teacher (Barker, Frisbie, & Patrick, 1993). However, with the introduction of information technologies to distance education, the definition continues to evolve. For example, Bates (1995) expands the definition beyond the simple separation of teacher and students to include the idea that learners can study in a flexible manner at the time and place of their choosing. While Cantelon (1995) adds the concept that "distance might just as easily be cultural or emotional, with quite different pedagogical implications" (p. 4). Finally, Lewis, Whitaker, and Julian (1995) offer a definition that expands upon the limiting assumption that the teacher always influences the learning that occurs. They write: "Distance education is the delivery of the educational process to receivers who are not in proximity to the person or persons managing or conducting the process" (p. 14).

Compounding the problem of developing a concise definition, 'distance education,' 'open learning,' and 'distance learning,' are often used interchangeably due to the extensive varieties of media, audiences, and programs involved world-wide. The inability to develop a succinct definition prompts Schlosser and Anderson (1994) to write "It it the nature of questions that they

are easier to ask than to answer. This is true of the question, what is distance education" (p. 1). Thus, the fundamental attributes of distance education seem to include: (1) separation of students and teacher or manager, (2) volitional student control, and (3) the use of media and some communicative process. The evolving nature of information technologies results in a similar inability of distance educators to develop a concise theoretical framework to which they all can subscribe.

Distance Education Theory

The dominant paradigm of mainstream education has consisted of grouping students for face-to-face instruction in institutions we call schools. As implied by the various definitions, distance education reverses the centralized school theme (where students, teachers, and resources are collocated) by bringing the "school" to the students (Holloway & Ohler, 1995). Although researchers and educators understand that distance education breaks the schooling paradigm, it was not until the late 1960s and early 1970s that researchers began to discuss the theoretical underpinnings of this form of education as something distinct from instructional television, a similar but narrower concept. Coincidentally this period witnessed rapid technology growth resulting in a continuing evolution of theory development.

Amundsen (1993) provides a concise discussion of the evolution of distance education theory by providing a synthesis of six prominent theoretical frameworks (p. 71; see table 1 on page 6). She points out that the major themes focus on the learner and communication, but centers her analysis on how each theorist "treats the definitive feature of distance education: the separation of the teacher and student" (p. 70).

Amundsen (1993) writes: "In the first four frameworks discussed (Peters, Moore, Holmberg, and Keegan), separation or distance is the focal point around which their thinking seems to be organized" (p. 70). For example, Peters places positive value on separation between learner and teacher because this leads to more individualized technology and decentralized decision-making, which reflect values of a postindustrial society. Moore and Holmberg, on the other hand, each place positive value on separation because distance enhances learner autonomy which, in turn, increases motivation to learn. Meanwhile, Keegan views distance as an obstacle to overcome, since distance severs the face-to-face learning link that exists in conventional education. Keegan (1986) believes that successful distance education requires the reintegration of the teaching and learning acts to mirror, as closely as possible, the learning environment in traditional education:

> The intersubjectivity of teacher and learner, in which learning from teaching occurs, has to be artificially recreated. Over space and time a distance system seeks to reconstruct the moment in which the teaching-learning interaction occurs. The linking of learning materials to learning is central to this process. (Keegan, 1986, p. 120)

Finally, while separation represents a barrier, it does not occupy a central position in either Garrison's or Verduin and Clark's theories. Each of these authors advocates the use of technology to facilitate the student-teacher interaction, which overcomes the barrier of distance. Consistent with the evolutionary nature of technology, these theories demonstrate technology's potential to overcome the problem of physical separation.

Framework	*Central Concepts*	*Primary Focus*
Peters (1967)	Industrial; postindustrial	Match between societal principles and values
Moore (1972)	Transactional distance Learner autonomy	Perceived needs and desires of the adult learner
Holmberg (1983)	Learner autonomy Non-contiguous communication Guided didactic conversation	Promotion of learning through personal and conversational methods
Keegan (1986)	Reintegration of teaching and learning acts	Recreation of face-to-face learning
Garrison (1987) (Shale, Baynton)	Educational transaction Learner control Communication	Facilitation of the educational transaction
Verduin and Clark (1991)	Dialogue/support Structure/specialized competence General competence/self-directedness	Requirements of both the learning task and learner

Table 1. Comparison of Theoretical Frameworks. Adapted from Amundsen (1993).

While this analysis points to the ability of technology to mitigate the negative effects of distance, a trend toward emphasizing the positive values of interactive communication and greater learner control becomes evident. Garrison (as cited by Amundsen, 1993) best illustrates this point; he rejects the notion of the lone learner because he believes the learning process requires interaction with a teacher (two-way versus one-way communication). Further, this educational transaction supports learner control which "is based on the interrelationship between independence (as in self-directed learner), proficiency (as in the ability to learn independently), and support (characterized by the resources available to guide and facilitate the educational

transaction)" (Amundsen, 1993, p. 68). Thus the trend in distance education theory is moving toward the norms of conventional education:

> Technological advances and new philosophies of distance education have resulted in a new paradigm of distance education, its goal to offer to the distance student an experience as much like that of traditional, face-to-face instruction as possible....Further advances are inevitable, resulting in greater "transparency" of distance education technology offering greater similarity with traditional classroom instruction. (Schlosser & Anderson, 1994, p. 14)

Garrison's framework demonstrates that technology enables distance education instruction to move toward greater similarity with traditional classroom instruction (i.e., better teacher-student interaction); however, the social context of learning remains conspicuously absent from Garrison's theory. Wolcott (1996) addresses this deficiency. Rather than dwell on physical distance, Wolcott identifies psychological distance as more troublesome. "It is time we shift our attention...to how to keep from further distancing learners in a psychological and social sense" (Wolcott, 1996, p. 23). She argues that spatial distance impedes the ability to develop a sense of rapport among participants, because spatial distance closes or restricts the communication channels. Although technology helps to mitigate this problem, technology also alters the communication patterns, robbing the communication environment of its richness. This in turn restricts or alters patterns of interaction. Since education relies on communication to build "a sense of community among learners" (p. 24), the decreased rapport and student-student interactions combine to increase psychological distance. As psychological distance increases, students "separated from the teacher, other students, and the locus of instruction" (p. 24) feel isolated and miss out on social and instructional interactions.

The question for distance educators then becomes how to best use technology to facilitate the educational transaction described by Garrison, while also establishing the community of learners discussed by Wolcott. This is a question of teaching practice, and if "good distance education pedagogy is good pedagogy in any classroom" (Schlosser & Anderson, 1994, p. 14), the question becomes, "what is good pedagogy?"

Good Pedagogy

What indeed, is good pedagogy? This question is best addressed in relation to the goals of education. Perkins (1991) offers the following goals for education: retention, understanding, and active use of the knowledge and skills (transfer). The effectiveness of education depends on establishing a learning environment that promotes these goals, otherwise inert knowledge accumulates (Whitehead, 1929). Perkins (1991) states:

> Surely we want what is taught retained, else why teach it? Unless knowledge is understood, to what purposes can it be put? Finally, having and understanding knowledge and skills come to naught unless the learner actually makes active use of them later in life. (p. 18)

Bransford and Vye (1989) support Perkins' assertion. Their review of cognitive research demonstrates that inert knowledge forms from memorizing information outside its context of use, and remains inert even when it is relevant to new situations. Achieving Perkins' educational goals requires sound teaching practice.

According to McLaughlin and Talbert (1993), sound teaching practice involves teaching for understanding. In addition to in-depth and comprehensive knowledge of the subject domain, teaching for understanding requires teachers to possess "competence in representation and manipulation of this knowledge in instructional activities, and skill in managing classroom

processes in a way that enables active student learning" (McLaughlin & Talbert, 1993, p. 2). In other words, teaching for understanding requires thorough knowledge of how to teach (good pedagogy), which, many educational scholars agree, results in an environment where students can "master new knowledge and skills, critically examine assumptions and beliefs, and engage in an invigorating, collaborative quest for wisdom and personal, holistic development" (Eastmond & Ziegahn as cited in Jonassen, et al., 1995, p. 7). In sum, good pedagogical teaching practice creates a learning environment that is experiential and activity-based (Dewey, 1938). This description of good pedagogy bears a strong resemblance to constructivism.

Constructivism

What is constructivism? Constructivism is a philosophy centered on the belief that each individual creates meaning (knowledge) from personal experience rather than just receiving knowledge transferred from someone else. "The mind is the instrument of thinking which interprets events, objects, and perspectives rather than seeking to remember and comprehend an objective knowledge" (Jonassen, et al., 1995, p. 11). Further, knowledge construction occurs, not in isolation, but through interactive discourse with peers and teachers (Resnick, 1991; Garrison, 1993; Grabinger, 1996). To facilitate "meaning making", educators should create constructivist learning environments which Wilson (1996) defines as "place[s] where learners may work together and support each other as they use a variety of tools and information sources in their guided pursuit of learning goals and problem-solving activities" (p. 5). Within a constructivist learning environment, the teacher's job involves creating authentic learning contexts for students (Wiggins, 1993; Jonassen, et al., 1995; Grabinger, 1996), and guiding and motivating students to "examine thinking and learning processes; collect, record, and analyze data; formulate and test

hypotheses; reflect on previous understandings; and construct their own meaning" (Crotty, 1994, p. 31). This active process of critical thinking, analysis, and reflection, ensures continuous knowledge generation, which prevents inert information accumulation (Grabinger, 1996). Learning requires interaction with "content" as well as people (Berge, 1996), and a constructivist approach to teaching and learning provides the means to achieve both forms of interaction.

If only it were that easy to capture the discussion surrounding constructivism. Phillips (1995) writes that "many varieties of constructivism...presently exist" (p. 5). He offers a framework for comparing constructivism along three dimensions: (1) individual construction of knowledge versus the construction of general human knowledge, (2) individual process or social and political processes, and (3) internal knowledge creation versus external knowledge imposition. The third dimension, apparently the most controversial and complex, "allows us to define a thinker as...constructivist. For there is a point somewhere along this continuum where one ceases to be a constructivist" (p. 7). Phillips (1995) characterizes the ideological posturing among educational scholars within this third dimension as "the ugly," but he believes the convergence of the various constructivist sects on emphasizing the active and engaged nature of learning and the recognition (by most constructivists) of a social context as "the good." Thus beyond a general definition of constructivism, considerable debate continues concerning the roles of the individual, groups of learners, and the teacher (see also Wilson, 1996; the May 1991 issue of Educational Technology, devoted to constructivism).

To illustrate Phillips' idea of a continuum, a debate currently exists between Garrison (1993) and Kemper (1994) concerning the designation of prepackaged distance education materials as constructivist or behaviorist. Garrison takes the position that prepackaged materials are

inherently not constructivist in nature. He believes that "reliance upon prepackaged self-instructional materials as a primary method of distance education reflects implicit assumptions regarding the teaching-learning process" (p. 199). Behaviorist in origin, these assumptions portray "...a static and standardized view of knowledge" where "feedback is simply whether responses are correct" (Garrison, 1993, p. 201). This behavioral orientation reflects a transmission approach to teaching versus a constructivist approach which stresses collaboration and creation of meaning.

In a rejoinder, Kemper dismisses the notion that prepackaged instructional materials are inherently behaviorist and lead to surface learning. Kemper (1994) argues "that prepackaged instructional materials can play a role in achieving understanding of complex and ill-structured subject areas and are compatible with a constructivist paradigm" (p. 153). He cites several studies suggesting that learners construct their own meaning from prepackaged materials, and that the teacher determines which type of learning environment exists.

Since considerable debate exists within the constructivist ranks, I offer the following basic principles, distilled from the forgoing discussion, as characteristic of a constructivist environment:

1. learning is active, collaborative, and goal oriented;
2. tasks should be challenging, authentic, and multidisciplinary;
3. performance-based, authentic assessment best measures what students learn;
4. interactive instructional methods encourage learners to construct knowledge in meaningful ways; and
5. the teacher functions as facilitator and co-learner.

Rather than argue from the abstract philosophical level, where broad definitions can have different meanings based upon people's assumptions about learning, I believe these five principles better frame the issue. Disagreement may still exist concerning the exact definitions and meanings of these principles, but the literature suggests that these principles capture the dynamic, iterative process of learning embraced by constructivist philosophy. Distance educators, therefore, can use these principles to design student-centered, collaborative learning environments to enhance learning.

Media versus Method

A common problem that exists among technically oriented people involves an infatuation with the latest, greatest technological wizardry. Clearly the emerging technologies have tremendous potential as constructivist teaching and learning tools. Berge and Collins (1995) write: "The active environment of social learning provided by a computer with access to local, national, and international networks increases interaction and communication among students, their teachers, peers, parents, and other members of the world community" (p. 3). What is equally clear, however, is that teachers can apply this potential only to the extent that their teaching and learning philosophies permit. In other words, Clark's (1994) argument that method, not media, influences learning, rings true. As Clark (1994) states:

> If learning occurs as a result of exposure to any media, the learning is caused by the instructional method embedded in the media presentation. Method is the inclusion of one of a number of possible representations of a cognitive process or strategy that is necessary for learning... (p. 26)

Wolcott's (1996) analysis of physical and psychological distance supports this argument. Physical distance restricts and may block communication. To some degree technology provides the means to overcome the problems associated with time and space displacement; however, technology also distorts the communication process. In a conventional classroom, for example, much of the information transmitted occurs through non-verbal behaviors and cues, which may be absent in the distance education environment. Effective methods help to overcome this deficiency; not just any methods, but adoption of learner-centered constructivist approaches. Before turning to a discussion of constructivist strategies available to distance education, the next section of the paper briefly discusses the prominent distance education models.

Distance Education Models

As one might expect, different authors view distance education models in various ways. James and Gardner (1995), for example, discuss distance education models from an evolutionary perspective. They recognize four generations of distance education models (generation one, correspondence study; generation two, audio and video teleconferencing; generation three, computers; and generation four, virtual reality) and analyze each based on such features as delivery system (media), communication channels, methods (group or individual), and interactive capabilities. Bates (1995), on the other hand, identifies four types of media (text, audio, television, and computing) and analyzes each based on the types delivery technology used, the format or styles of presentation, and interactivity. For example, text (the medium) uses either print or computers (the technology) to deliver course units and data bases (the format) via one-way application or two-way application (correspondence tutoring). Throw in other descriptors of distance education, such as telephone teaching, computer-based learning, and

teletext, and confusion reigns. Lewis, Whitaker, and Julian (1995) have summarized the salient features of distance education into four general models--(1) the correspondence model, (2) the multimedia model, (3) the telelearning model, and (4) the computer-mediated communication model. Their analysis provides the most focus, therefore, it serves as the basis for the brief discussion of distance education models that follows.

Correspondence Model

Distance education began with the correspondence model. American adult-oriented correspondence education began in the 1870's with the Chautauqua Institution (Jarvis, 1993). This form of education has been dominated by print, although audio and video cassettes are currently used to supplement the printed text. Lewis, Whitaker, and Julian (1995) describe this approach as teacher-centered, characterized by minimum interaction between teacher and student. Course materials are sent to the learner who interacts with the materials and receives feedback from the teacher after completing some end-of-course assessment activity. The object of this approach is "to reproduce the content of classroom teaching in the form of course notes for solitary individual students who are not expected to have any interaction with each other" (Lewis, Whitaker, & Julian, 1995, p. 14). James and Gardner (1995) believe that the self-paced nature of this approach, combined with a lack of sufficient and timely feedback, leads to effectiveness concerns. By interacting with the course materials students, do construct knowledge (some may even achieve critical thinking, analysis, and reflection). And as Bates (1995) argues, correspondence tutoring affords the opportunity for at least some student-teacher interaction to occur. However, it appears evident that this form of distance education falls short

of inclusion as a constructivist learning environment by violating, at a minimum, the social context element of learning.

Multimedia Model

The multimedia model represents the second generation model of distance learning. This model uses print, audio, and video, adds computer-based instruction, and encourages interaction through use of telephone, teleconferencing, and computer conferencing (Lewis, Whitaker, & Julian, 1995). Salient features of this model include: (1) a team approach to instructional design and development, (2) a stand-alone program that is expected to change little, (3) the use of embedded features to encourage a high degree of student-material interaction, (4) encouragement for higher degrees of teacher-student and student-student interaction.

On the basis of this description, one might conclude that this form of distance education can incorporate constructivist principles. This model, however:

> ...can be used by isolated students wherever they may happen to be. It moves away from the replication of what goes on in a typical classroom to a highly structured, interactive package which, although it is teacher directed, is for practical purposes under the students' control. Students can choose the time, place, pace, and approach to the material. (Lewis, Whitaker, & Julian, 1995, p. 15)

Thus the participants (teachers and students) determine whether or not this form of distance education embodies a constructivist learning environment based upon the extent to which they embrace the previously discussed principles. In other words, this environment is constructivist to the extent that students and teachers take advantage of the opportunity for high quality

interaction. What is constructivist for some students may be just a jazzed up correspondence course for others.

Telelearning Model

The telelearning model uses "audio- and videoconferencing and broadcast television to extend and reproduce the environment of the classroom" (Lewis, Whitaker, & Julian, 1995, p. 16). This model provides the opportunity for spontaneous interaction among students, but is dependent upon the teacher who directs the classroom environment (Lewis, Whitaker, & Julian, 1995). This model also uses a team approach to instructional design, development, and delivery. It is best illustrated by students assembling at one or more distance education sites and turning on the television to watch the distance teacher conduct class. Audio and video connections exist between the teacher and students to facilitate teacher-student interaction or site-facilitator to student interaction; since students are grouped together, the ability to stimulate student-to-student interaction also exists.

Much like the multimedia model, the participants (especially the teacher) in the telelearning model determine whether it is constructivist in principle. In particular, with the students grouped in a classroom, the social aspect of constructivism is much easier to encourage, but other constructivist values may be neglected (e.g. peer collaboration, self-directed learning, etc.).

Computer-Mediated Communication Model

"Computer-mediated communication (CMC) refers to the use of networks of computers to facilitate interaction between spatially separated learners; these technologies include electronic mail, computer conferencing, and on-line databases" (Jonassen, et. al, 1995, p. 16). Participants share ideas, thoughts, and information in a highly interactive (instructor-student and

student-student) environment through real-time (synchronous) and delayed (asynchronous) communications (Lewis, Whitaker, & Julian, 1995; Jonassen, et al., 1995). Lewis, Whitaker, and Julian (1995) list several advantages of CMC, such as:

1. asynchronous communication (promotes learner-self control by allowing queries to be logged at any time day or night and provides additional time to frame questions and answers);
2. bridging space and cultural differences; and
3. significantly reducing printing and material costs by putting course materials on-line--the computer not only delivers information but also stores it!

Certainly the aforementioned authors are exhilarated by CMC due to its advantages and capacity to support a collaborative, conversational environment. Jonassen et al. (1995) provide evidence that in traditional classrooms the teacher contributes up to 80% of the verbal interaction that occurs, while instructors contribute only about 10-15% of message interaction when using on-line computer conferencing. Bates (1995) is similarly excited by CMC, but tempers his enthusiasm by noting that some limitations exist. For example, he cites evidence of participation variability, the necessity for good design and moderating skills to ensure quality interactions, and the requirement for first time students and tutors to learn new computer and study skills. With the possible exception of learning new computer skills, every classroom teacher faces these obstacles. Clearly of the four models reviewed, CMC possesses the greatest "constructivist" potential, but again the participants (especially the teacher) determine whether this designation applies. The final section of this paper discusses constructivist approaches educators can use to maximize the learning potential of information technologies.

Constructivist Applications to Distance Education

To this point I have argued that constructivist principles relate very well to distance education environments and have highlighted the potential that each distance education model possesses for applying these principles. With the exception of the correspondence model, which fails to meet the social learning aspect of constructivism, each successive distance education model possesses greater capacity to facilitate interaction (content and interpersonal), leading to the educational goals of retention, understanding, and active use (Perkins, 1991).

Many constructivist strategies exist (e.g., anchored instruction, cognitive apprenticeship, case-based instruction, cooperative learning, etc.) which distance educators can use; below I briefly describe two options--problem-based learning and reciprocal teaching. Rather than provide an analysis for each distance education model, I limit my discussion to the computer-mediated communication model, which given its text-based nature, appears ideally suited to these two strategies. However, subscribing to Clark's (1994) view that any particular instructional method is usable with a number of media, problem-based learning and reciprocal teaching, as well as other constructivist strategies, are generally adaptable to the other models with little effort.

Problem-based Learning

Problem-based learning requires students to solve a problem or work toward an understanding of a problem (Grabinger, 1996). Typically students are grouped together in the problem-based learning environment. The group receives the problem and works collaboratively by questioning, summarizing, and hypothesizing to arrive at consensus on a final solution. After placing students in groups, the teacher's primary responsibility involves guiding and monitoring

each group's progress. Grabinger (1996) writes:

> PBL is the epitome of the...constructive learning process. Students work with problems in a manner that fosters reasoning and knowledge application appropriate to their levels of learning. In the process of working on the problem and with their peers, students identify areas of learning to guide their own individualized study. The skills and knowledge acquired by this study are applied back to the problem to evaluate the effectiveness of learning and to reinforce learning. The learning that has occurred in work with the problem and in individualized study is summarized and integrated into the student's existing knowledge structure. (p. 17)

Problem-based learning obviously satisfies the five principles of a constructivist learning environment previously discussed. Problem-based learning encourages student construction of knowledge through active and collaborative problem solving, discussion of relevant issues, and negotiation of interpretation. The problems and tasks assigned are typically challenging and authentic leading to more learner engagement because the learners become motivated to learn and explore more. The instructor's role involves coaching, modeling, and facilitating the processes to promote social interaction and critical thinking. Finally, it would be self defeating to establish this type of constructivist environment, but assess students in the traditional, objective manner. Since this strategy promotes retention, understanding, and active use, the teacher must incorporate assessment methods, such as group and individual writing samples and email conversations, to evaluate the thinking processes.

Reciprocal Teaching

Reciprocal teaching applies questioning, summarizing, clarifying, and predicting strategies as a means for reading comprehension in a collaborative environment (Brown & Palincsar, 1989; Grabinger, 1996). Typically the teacher models these behaviors and then guides the students as they take turns leading the discussion of readings. Each discussion leader asks questions, which the other students respond to, summarizes and synthesizes the group discussion, and generates predictions about upcoming readings. Within the CMC environment, reciprocal teaching involves alternating control and responsibility between teacher and students. As facilitator, the instructor's primary role involves encouraging participation and flexibly guiding discussion to increase social interaction and higher levels of learning. "With the help of the teacher, students share a zone of proximal development where they can learn the questioning, summarizing, clarifying, and predicting activities so integral to metacognitive awareness" (Grabinger, 1996, p. 15). Clearly, reciprocal teaching benefits learners by creating a learning environment very similar to the type of environment that a problem-based learning approach produces. As stated earlier, PBL and reciprocal teaching, as well as other constructivist strategies, are adaptable to other the distance education models provided the distance educator decides to take a learner-centered approach.

Conclusion

Although about a century old, distance education continues to pick up steam as the proliferation and affordability of powerful information technologies (microcomputers and telecommunications technologies) increase. As these technologies merge with a dynamic American society, the domain of distance education expands to include new kinds of students.

Distance education no longer belongs solely to solitary adult workers taking correspondence courses in their spare time; now the traditionally disenfranchised, school children, and college students can take advantage of distance education's capabilities to bring a wealth of information and knowledge to their classrooms and homes. With this process well under way, distance educators, scholars, and researchers:

> ...are now beginning to focus on a related set of notions: (a) there are different learning styles, (b) students create their own meaning when learning new things, and (c) what makes a difference in content retention and transfer is not so much what is done by teachers, but what students as learners can be encouraged to do themselves. (Berge & Collins, 1995, p. 4)

Given the paucity of existing research merging constructivism and distance education, this expanded research effort is an overdue, but welcome development. As stated earlier, simply using technology to transmit information from teachers to learners does not guarantee successful learning outcomes. Achieving Perkins' (1991) educational goals requires a shift from a teacher transmission model of distance education to a learner-centered approach. "If the goal of distance education is to facilitate learners in their construction of meaning, then methods, materials, and evaluation must be congruent with that goal" (Garrison, 1993). Distance educators must use the interactive capabilities of communications technologies to create constructivist learning environments to align the goals and methods of distance education. In sum, distance education will be more effective when learning occurs within stimulating environments designed on constructivist principles (Jonassen, et al, 1995).

References

Amundsen, C. (1993). The evolution of theory in distance education. In D. Keegan (Ed.)., Theoretical principles of distance education (pp.61-79). New York: Routledge.

Bates, A. W. (Tony) (1995). Technology, open learning and distance education. New York, NY: Routledge.

Barker, B. O., Frisbie, A. G., & Patrick, K. R. (1993). Broadening the definition of distance education in light of the new telecommunications technologies. In K. Harry, J. Magnus, & D. Keegan (Eds.), Distance education: New perspectives (pp. 39-47). New York: Routledge.

Bednar, A. K., Cunningham, D., Duffy, T. M., & Perry, J. D. (1995). Theory into practice: How do we link? In G. J. Anglin (Ed.), Instructional technology: Past, present, and future (pp. 100-112). Englewood, CO: Libraries Unlimited, Inc.

Benton Foundation (1995, September). Communications Policy Project: The Learning Connection. [On-line]. Available: http://www.benton.org/cgi-bin/lite/Goingon/learning.html

Berge, Z. L. (1996). The role of the online instructor/facilitator. [On-line]. Available: http://cac.psu.edu/~mauri/moderate/teach_online.html

Berge, Z. L., & Collins, M. P., (Eds.). (1995). Computer-mediated communication and the online classroom, vol 3: Distance learning. Cresskill, NJ: Hampton Press, Inc.

Bransford, J. D., & Vye, N. J. (1989). A perspective on cognitive research and its implications for instruction. In L. B. Resnick & L. E. Klopfer (Eds.), Toward the thinking curriculum: Current cognitive research (pp. 173-205). Alexandria, VA: ASCD.

Brown, A. L., & Palincsar, A. S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. B. Resnick (Ed.), Knowing and learning: Issues for a cognitive psychology of learning. Essays in honor of Robert Glaser, (pp. 393-451). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Cantelon, J. E. (1995). The evolution and advantages of distance education. In M. H. Rossman, & M. E. Rossman (Eds.), Facilitating distance education (pp. 3-10). San Francisco: Jossey-Bass Publishers.

Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42 (2), 21-29.

Crotty, T. (1994). Integrating distance learning activities to enhance teacher education toward the constructivist paradigm of teaching and learning. In Distance Learning Research Conference Proceedings, 31-37. College Station, TX: Department of Education and Human Resource Development, Texas A&M University.

Dewey, J. (1938). Experience and education. New York: Collier Books.

Garrison, D. R. (1993). A cognitive constructivist view of distance education: An analysis of teaching-learning assumptions. Distance Education, 14 (2), 199-211.

Grabinger, R. S. (1996). Rich environments for active learning. In D. H. Jonassen (Ed.), Handbook on instructional technology research. New York: Scholastic Press.

James, W. B. & Gardner, D. L. (1995). Learning styles: Implications for distance learning. In M. H. Rossman, & M. E. Rossman (Eds.), Facilitating distance education (pp. 19-31). San Francisco: Jossey-Bass Inc., Publishers.

Jarvis, P. (1993). The education of adults and distance education in late modernity. In D. Keegan (Ed.), Theoretical principles of distance education (pp. 165-174). New York: Routledge.

Jonassen, D., Davidson, M., Collins, M., Campbell, J., & Haag, B. B. (1995). Constructivism and computer-mediated communication in distance learning. The American Journal of Distance Education, 9 (2), 7-26.

Keegan, D. J. (1986). The foundations of distance education. London: Croom Helm.

Kember, D. (1994). The teacher is more important than the medium: Pre-packaged instructional material are not axiomatic with surface learning. Distance Education, 15 (1), 153-159.

Lewis, J., Whitaker, J., & Julian, J. Distance education for the 21st century: The future of national and international telecomputing networks in distance education. In Z. L. Berge & M. P. Collins (Eds.), Computer-mediated communication and the online classroom, vol 3: Distance learning (pp. 13-30). Cresskill, NJ: Hampton Press, Inc.

Miller, C. D., & Clouse, R. W. (1993-1994). Technology-based Distance Learning: Present and future directions in business and education. Educational Technology Systems, 22 (3), 191-203.

McLaughlin, M. W. & Talbert, J. E. (1993). Introduction: New visions of teaching. In D. K. Cohen, M. W. McLaughlin, & J. E. Talbert (Eds.), Teaching for understanding: Challenges for policy and practice (pp. 1-10). San Francisco: Jossey-Bass Inc., Publishers.

NRENAISSANCE Committee (1994). Realizing the information future: The internet and beyond. Washington D.C.: National Academy Press.

Perkins, D. N. (1991). Technology meets constructivism: Do they make a marriage? Educational Technology, 31 (5), 18-23.

Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. Educational Researcher, 24 (7), 5-12.

Resnick, L. B. (1991). Shared cognition: Thinking as social practice. In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), Perspectives on socially shared cognition. Washnington, DC: American Psychological Association.

Resnick, L. B., & Resnick, D. P. (1992). Assessing the thinking curriculum: New tools for educational reform. In B. R. Gifford, & M. C. O'Connor (Eds.), Changing assessments: Alternate views of aptitude, achievement and instruction (pp. 37-75). Boston: Kluwer.

Schlosser, C. A. & Anderson, M. L. (1994). Distance education: review of the literature. Washington D.C.: Association for Educational Communications and Technology.

Whitehead, A. N. (1929). The aims of education and other essays. New York: The Macmillan Company.

Wiggins, G. (1993). Assessment: Authenticity, context, and validity. Phi Delta Kappan, 75, 200-214.

Wilson, B. G. (ed.), (1996). Constructivist learning environments: Case studies in instructional design. Englewood Cliffs, NJ: Educational Technology Publications.

Wilson, B. G. (1996). Reflections on Constructivism and Instructional Design. In C. Dills, & A. Romiszowski (Eds.), Instructional development. Englewood Cliffs, NJ: Educational Technology Publications.

Wolcott, L. L. (1996). Distant, but not distanced: A learner-centered approach to distance education. TechTrends, 23-27.